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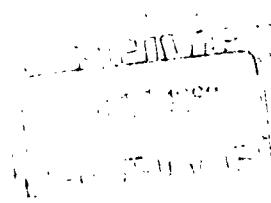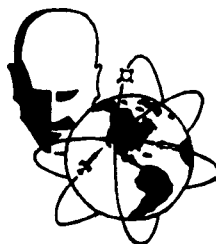ESD-TDR-63-159   SR-79

STATISTICAL ASSOCIATION PROCEDURES
FOR MESSAGE CONTENT ANALYSIS

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-63-159

April 1963

J. Spiegel   E. Bennett   E. Haines

Prepared for

OPERATIONAL APPLICATIONS LABORATORY

ELECTRONIC SYSTEMS DIVISION

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UNITED STATES AIR FORCE

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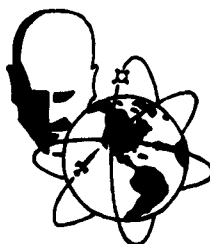
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STATISTICAL ASSOCIATION PROCEDURES FOR MESSAGE CONTENT ANALYSIS
MITRE SR-79   Information System Language Studies, Number 1

by

J. Spiegel, E. Bennett, and E. Haines of the System Sciences
Department and R. Vicksell and J. Baker of the Computer Appli-
cations Department.

FOREWORD

This paper is substantially the same as "Document and Message
Routing through Communication Content Analysis," presented at
the International Federation for Information Processing Congress,
Symposium on Optimum Routing in Large Networks, in Munich,
31 August 1962.

ABSTRACT

This is an introductory report of an investigation
concerned with developing procedures for utilizing certain
statistical properties of messages or documents; these
properties to be used for message routing or retrieval.
This approach applies the most elementary relation among
the words making up a message that of word-word co-occurrence
probability patterns. It is shown that any message material,
be it natural language, code, or index terms, can be proc-
essed provided that the input is compatible with the input
requirements of the computer.

iii

TABLE OF CONTENTS

STATISTICAL ASSOCIATION PROCEDURES FOR MESSAGE CONTENT ANALYSIS

THE DEVELOPMENT OF A METHODOLOGY FOR STATISTICAL ASSOCIATION

Approach to the Problem

The work of this investigation is concerned with developing
procedures for coding certain statistical properties of messages (or
documents) contained within an information system, and then using these
codes for message routing or retrieval The statistical approach
applies the most elementary relation among message units, that of
co-occurrence probability patterns. The basic strategy is to proceed
as far as possible with a minimum of assumptions about the linguistic or
semantic organization of the information within the message structure.

This strategy implies a rather mechanistic approach to language
processing and that is indeed the case. We assume the information con-
tained in a message is carried by the words that make it up, and by the
manner in which they are strung together. Further, we assume a person
generating a message or document chooses words in a nonrandom fashion
and combines them according to semantic and syntactic rules that are
regular and, at least in our culture, to some extent predictable. That
is, both the selection of elements and their co-occurrence with other
elements are subject to restrictions by the contexts in which they occur.
Evidence from information redundancy experiments indicates such an assump-
tion is reasonable. We intend to exploit the regularities of these an

sociations among words, ignoring the specific nature of the rules which
produce such regularity and thereby restricting ourselves to coding and
use of the resulting statistical features alone.

Before discussing specific coding and routing or retrieval tech-
niques, it is clear certain ideals or requirements should be taken into
account. First, any machine technique for coding messages should be able
to accept and analyze large amounts of natural message content relating
to a wide range of topics. In responding to retrieval search or routing
demands, a routing technique should be able to draw upon its total re-
source of stored content coded information, not only to select an ap-
propriate response, but more important, to improve its program for inter-
preting such demands and responding to them. Both techniques should be
able to improve with experience, and the combined system of the two tech-
niques should be able to accept and use program or procedural information
in the same form as any other input, including data. The system should
be able to code the content from messages in a fully mechanical manner.
It also should be able to relate new content to other statistically rele-
vant content already in memory. From its reservoir of information, it
should be able to elicit the necessary clues as to which messages are
relevant to each other, especially in response to a message which is also
a query. For such a system to be reasonably adaptable, it also should be
able to perform these functions without an index, grammar book, dictionary,
thesaurus or other formal constraint.

In reviewing these requirements it is evident that we are defining an approach similar in many ways to the way humans appear to retrieve information from their own memories.[1] Typically, humans seem to start with the query words and then associate these with other words until the information they seek is brought to their conscious attention. This process of association of elements is so basic and obvious that Aristotle reasoned that to learn was to associate. However, although association theory has been known for many years, little use has been made of it as a methodology for information processing. In fact, literature on the use of statistical associations for information processing is quite limited, although at least three significant contributions of a methodological nature appear to be of direct relevance. All are concerned with the use of index terms, from a specified library of index terms, to retrieve documents from a specified library of documents. All involve obtaining descriptive statistics to indicate the extent to which specific index terms occur together in tagging the various documents of the library. Such descriptive statistics then are used to expand from one or more index terms used in a query to a set of associated terms, based upon evidence of the co-occurrence tendencies of the various terms.

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[1] For an interesting example of one way humans retrieve, see Freud (1938, p. 57A). References are listed by name and date at the end of the report.

Previous Research on Statistical Association Techniques

Maron and Kuhns (1960) investigated statistical association techniques as part of a more general methodological attack on the problem of document retrieval. Starting with a catalog of index terms, and a library of documents, a statistical matrix of association frequencies is developed.

	T_k	$\bar{T}_k$	
T_j	$x=N(T_j,T_k)$	$u=N(T_j,\bar{T}_k)$	$N(T_j)$
$\bar{T}_j$	$v=N(\bar{T}_j,T_k)$	$y=N(\bar{T}_j,\bar{T}_k)$	$N(\bar{T}_j)$
	$N(T_k)$	$N(\bar{T}_k)$	n

where

T_j is a tag in the original request.

T_k is a tag not in the original request.

$N(T_j,T_k)$ = the number of documents in the library tagged jointly with both T_j and T_k.

$N(T_j,\bar{T}_k)$ = the number of documents tagged with T_j and not with T_k.

$N(T_j)$ = the total number of documents tagged with T_j.

$N(\bar{T}_j)$ = the total number of documents not tagged with T_j.

n = the total number of documents, and so forth.

From these descriptive statistics, Maron and Kuhns develop three different measures of closeness of association for index terms. One is the conditional probability that if a term in the original request T is assigned to a document, then the additional term T_j also will be assigned:

$$P(T_k|T_j) = \frac{N(T_j,T_k)}{N(T_j)}$$

(1)

The second measure is the inverse conditional probability; that is, the probability that if the additional term T_k is assigned to a document, then the original request term T_j also would be:

$$P(T_j|T_k) = \frac{N(T_j,T_k)}{N(T_k)}$$

(2)

Finally they use the contingency estimate, or estimate of the frequency of co-occurrence, independent of the individual and separate influences of the two terms which form the co-occurrence in question. They remove the magnitude to be expected on the basis of chance from the actual cell magnitude, taking into account the number of times the individual tags are used.

$$\delta(T_j,T_k) = N(T_j,T_k) - \frac{N(T_j)\ N(T_k)}{n}$$

(3)

Maron and Kuhns then introduce an arbitrary coefficient of association, based upon $\delta(T_j,T_k)$, which ranges conveniently from -1 to +1 with a magnitude of zero for the condition were $\delta(T_j,T_k)$ is zero. This co-

6

efficient is of the form:

$$Q(T_j, T_k) = \frac{n\delta}{(xy + uv)} \tag{4}$$

Stiles (1961) also starts with a contingency table of the form previously noted. However, he introduces a different coefficient of association:

$$\log_{10} \frac{n\left(|n\delta| - \frac{n}{2}\right)^2}{N(T_j)\ N(T_k)\ N(\bar{T}_j)\ N(\bar{T}_k)} \tag{5}$$

Doyle (1960) uses still a third measure also drawn from a contingency table, to indicate strength of association:

$$\frac{N(T_j, T_k)n}{N(T_j)\ N(T_k)} \tag{6}$$

In each of the three approaches cited, the investigators tend to adopt the same basic data structure from which to develop their analyses. They pass over the question of how many terms are used to index any particular document and start with the total population of indexed documents as a base. They divide this population of documents into those that exhibit the common property of having been indexed by T_j, with and without T_k, and those not indexed by T_j, with and without T_k. Using various normalizing procedures, they adjust the sizes of these various groups, especially the group T_j, T_k, to remove any effect that might result from the tendencies of T_j and T_k, separately, to occur frequently in general. Some kind of normalization is required, because the more frequently an index word occurs, the more likely it will co-occur with some other term, simply on the basis of chance. The techniques used by Maron and Kuhns,

Stiles, and Doyle, however, do not treat the fact that the more lengthy the string of index words used to index a document, the more likely that co-occurrences involving the terms in the string are due to chance.

For a library retrieval problem this might be little more than a minor omission, if, for example, the number of terms used to index all documents is a constant. However, if data on statistical co-occurrence are drawn from the actual strings of words in natural language that comprise the body of a document or message, then such factors as string length, word position in the string, and vocabulary size might significantly influence the tendency of words to co-occur. Accordingly, we would like to argue that a statistical association technique should take into account such factors and, further, that it should not be dependent upon the particular level of message aggregation being considered.

Preliminary Considerations for a Statistical Association Methodology

Before discussing a method for accounting for these effects, it would be useful to define our terms and examine their implications. As previously stated, the message is a carrier of information or content. The smallest message carrier of content is probably the alphabetical letter, number, or arbitrary punctuation mark. This is a message of minimum size. A continuous string of such marks, commonly a word, may be thought of as a somewhat larger message. At a still larger level of aggregation, a string of words, perhaps a sentence or a paragraph, is also a message. Similarly, documents, books, clusters of books, and so

forth, are messages of increasing levels of aggregation.

Analytical techniques for determining message or document content do not necessarily have to change radically because of the magnitude of message aggregation being considered. The procedures one uses to examine the subject matter index of a library card file may be similar to the procedures for understanding and searching the individual book cards, which in turn may parallel the procedures used with a book's table of chapter contents, its page index, or the paragraphs and sentences of an individual page itself.

Therefore, to maintain stress upon the common denominator, we will consider all of the strings that constitute messages as a class, becoming specific, when necessary, by indicating the size or level of aggregation for any string. Alphabetical, numerical, or punctuation mark messages are one level of aggregation smaller than those considered in detail at this point. The units of immediate concern are words, strings consisting of a few words, and strings of such strings, including those larger strings that range from sentences or titles, to paragraphs or abstracts, to articles, and so forth.

We establish the following working definition: a word type is the smallest unit of analysis and always has the identical configuration of alphabetical, numerical, and conventional marks. Thus, the word type man is different from men or man's. Similarly is, are, and am are dif-

ferent types. Types may vary in size from one symbol to many. The only
requirement is that the symbol arrangement remains the same for the same
type.

The ability of a person to react differently to the string of letters
<u>man</u> in contrast to the string <u>men</u>, <u>man</u>, or <u>manx</u> reflects the influence
of differing structural arrangements of identifiable elements. The
string <u>man</u> is a unique system that might be represented by the simple
flowgraph below in which the numbers give the distance between the ele-
ments of the string
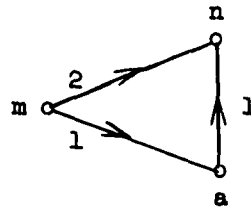
or, by the somewhat more redundant association list
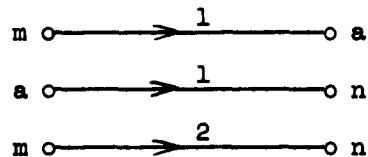
The arrangement or association of words can be represented in
the same way to identify a sentence, or the association of sentences
can identify a paragraph. This also applies to messages of larger ag-
gregation. For example, the string <u>Mary would like John</u> has an identity
characterized by the co-occurrence of the four words, the specific se-
quence of the words, and the distance among them:
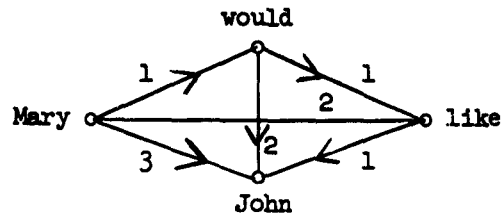
In association list form the string would have the representation:
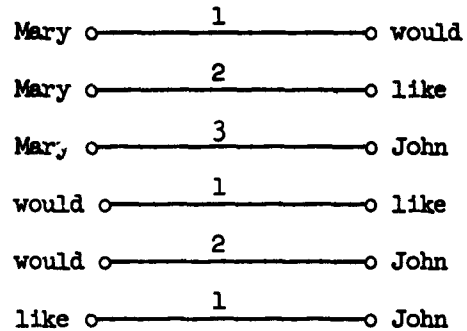
In this way a message at any level of aggregation can be represented structurally by its co-occurring units at the next lower level by merely specifying the directions and distances among them.

As further illustration consider the following title, descriptors, and abstract[2] as one message:

(<u>title</u>)   Psychophysical relations in the visual perception of length, area and volume.

---

[2]Armed Services Technical Information Agency No. AD-262 148 (30 August 1961).

(<u>descriptors</u>)   Visual perception, Perception, Stimulation, Tests,
Measurement.

(<u>abstract</u>)   Subjective length, area and volume as functions of
the corresponding stimulus variables were studied
in three experiments. The exponents of the psycho-
physical power functions scattered around 1 for per-
ception of real space. For perspective drawings of
cubes and spheres, however, the exponents were about
0.75. It was tentatively concluded that perspective
is an insufficient cue to visual volume. The results
are discussed with special reference to certain carto-
graphic symbols representing population magnitude.

Just for this example, we will establish the following convention.

A word type is any unique sequence of exclusively alphabetical symbols

with one or more blank spaces preceding and following it, but without

blank spaces in the sequence itself. Capital and lower case letters are

to be considered identical, and all numbers and punctuation are ignored

in identifying types. A primary string is specified as terminating with

the presence of a punctuation mark directly followed by two or more

spaces. This specification results in choosing as primary strings those

sequences of words that correspond to what we ordinarily identify as

sentences. Accepting these conventions we can represent the message as

a secondary string composed of sentence length primary strings:

Psychophysical relations in the visual perception of length
area and volume. Visual perception stimulation tests measure-
ment. Subjective length area and volume as functions of the
corresponding stimulus variables were studied in three experi-
ments. The exponents of the psychophysical power functions
scattered around for perception of real space. For perspective
drawings of cubes and spheres however the exponents were about.
It was tentatively concluded that perspective is an insuffi-
cient cue to visual volume. The results are discussed with
special reference to certain cartographic symbols representing
population magnitude.

12

This message, or any part of it, also can be represented by an association matrix, where the columns represent the first word in a pair, the rows represent the second word, and the cell entries indicate the frequency for each of the co-occurrences. This matrix is, in effect, a simple coded representation of part of the structural content of this one message. With the addition of other messages from the same corpus, the matrix could gradually grow to reflect the co-occurrences of types in all the messages of the corpus in question. This matirx would reflect the statistical structure of the corpus, showing which types were associated and to what extent.

The Development of a Statistical Association Technique

The actual frequency of occurrence of any pair of word types is partially a function of the relevant tendency for the two word types to co-occur because they are associated in some meaningful manner. However, it is also a function of the separate tendencies, irrelevant for this purpose, of either of the word types to occur with all other word types in general. For example, a specific word type will be the first type in as many pairs as there are other types following it in a string. Similarly it will be the second type in as many pairs as there are other types preceding it in a string. A word type will also form pairs as a function of how frequently it occurs as a type in the set of strings under consideration.

It is desirable to normalize to eliminate these extraneous influences: frequency of word occurrence, relative word position, and string length. This can be accomplished by subtracting from the actual

frequency of pair occurrence an estimate of the frequency expected on the basis of chance and position of occurrences as well as sentence length for each of the two words that comprise the pair in question, as follows. We start with a matrix of frequencies of co-occurrences:

FIRST POSITION

	x_j	x_k	$(\not{x}_j, \not{x}_k)$	
y_j	$N(x_j, y_j)$	$N(x_k, y_j)$	$N\big((\not{x}_j, \not{x}_k), y_j\big)$	$N(y_j)$
y_k	$N(x_j, y_k)$	$N(x_k, y_k)$	$N\big((\not{x}_j, \not{x}_k), y_k\big)$	$N(y_k)$
$(\not{y}_j, \not{y}_k)$	$N\big(x_j, (\not{y}_j, \not{y}_k)\big)$	$N\big(x_k, (\not{y}_j, y_k)\big)$	$N\big((\not{x}_j, \not{x}_k), (\not{y}_j, \not{y}_k)\big)$	$N(\not{y}_j, \not{y}_k)$
	$N(x_j)$	$N(x_k)$	$N(\not{x}_j, \not{x}_k)$	N_o

S
E
C
O
N
D

P
O
S
I
T
I
O
N

where

$N(x_j, y_j)$ = the frequency of co-occurrences with word type j preceding word type j.

$N(x_j, y_k)$ = the frequency of co-occurrences with word type j preceding word type k.

$N(x_j, (\not{y}_j, \not{y}_k))$ = the frequency of co-occurrences with word type j preceding token which are not of word type j and not of word type k.

$N(x_j)$ = the sum of the frequencies of all co-occurrences with word type j in the first position.

$N(y_j)$ = the sum of the frequencies of all co-occurrences with word type k in the second position.

N_0 = the grand total frequency of co-occurrences.

The total frequency of pairs that includes the word type j in the first position, $N(x_j)$, is equal to the portion of the length of the string that follows the type j, summed over the total number of occurrences of the type. Similarly the total frequency of pairs that includes the type k in the second position, $N(y_k)$, is equal to the length of the string that precedes the type k, summed over the total number of occurrences of the type.

The row and column totals $N(x_j)$, $N(x_k)$, $N(y_j)$, $N(y_k)$ and so forth, supply a statistical estimate of the cell magnitude that could be expected because of the extraneous factors of frequency, position, and

string length. Subtracting the customary contingency table correction[3] from the actual cell magnitudes, this estimate of cell magnitude can serve as a first level normalization.

Even with this correction, the cell frequencies are still a function of the actual magnitude of the total corpus of pairs and the total number of word types included in the entire matrix. Thus the greater the total number of pairs, the greater the number to be expected in any cell. Similarly, the fewer the number of word types, the fewer the number of matrix cells, and, therefore, the greater the number of pairs to be expected in any one cell. Consequently, correction of cell frequencies proportional to the total frequency of pairs and inversely proportional to the number of matrix cells results in a set of weights which is normalized for extraneous factors. The resultant cell weights, Zs, serve as one estimate of the influence of association forces independent of individual frequencies, sentence lengths, number of different types and total number of pairs within the corpus under consideration:

$$Z(x_j, y_k) = n^2 \left[\frac{\overline{N(x_j, y_k)}}{N_o} - \frac{N(x_j)N(y_k)}{N_o^2} \right]$$

---

[3]Note that this initial correction is identical to the contingency table correction made by Maron and Kuhns, and Stiles on their matrix tabular data, although these investigators use row and column totals based upon frequency of type occurrence, ignoring the variable of how many types are used to identify a document (our notion of string length).

where

$N(x_j, y_k)$ = the frequency of co-occurrence of types i and j.

$N(x_j)$ = the total frequency of co-occurrences with token i as first type.

$N(y_k)$ = the total frequency of co-occurrences with type j as second type.

N_o = the total frequency of co-occurrence of all types.

n = the number of different types.

When the direction of co-occurrence is not considered, the matrix can be collapsed into triangular form which reflects joint occurrence, where pairs with the words reversed in direction are combined. Each matrix cell of such a triangular matrix, except the cell where j equals k, is, in effect, the sum of two cells

$$N(x_j, y_k) \quad + \quad N(x_k, y_j)$$

In this case, the correction for extraneous factors would be:

$$Z'(x_j, y_k) = \frac{n(n+1)}{2} \left[\frac{N(x_j, y_k) + N(x_k, y_j)}{N_o} - \frac{N(x_j + y_j) N(x_k + y_k)}{2N_o^2} \right]$$

where $N(x_j + y_j)$ = the total frequency of pairs containing type j in either position. Therefore, $N(x_j, y_j)$ is counted twice.

If the matter of distance of displacement of the words in the pairs is ignored for the moment, a matrix of co-occurrences based upon the statistic $Z'(x_j, y_k)$ would appear to reflect one statistical tendency of pairs of types to associate. The matrix is adaptive in that it starts

with no cell weights if there has been no input of strings. Then as the inputs begin and continue, the matrix continues to grow and change as it digests ever-increasing quantities of pairs. Each normalized cell weight, Z', rises and falls with time as each specific association increases or decreases in relative frequency. In this way, the matrix memory of associations changes with time, maintaining a cumulative pattern of associations reflecting one statistical characteristic of messages fed into it in the past.

In addition to this adaptive characteristic of changing memory with time and with changes in inputs, the matrix is also readily subject to formal education. Any specific cell weight can be strengthened by repeatedly reading into the matrix memory the specific strings that contain the desired association. For example, by introducing the strings is am, is are, am is, am are, are is, and are am, we can increase the statistical tendency of the tokens is, am, and are to be associated.

More complex learning can be accomplished by the introduction of strings such as man men, men man, singular plural, plural singular, man singular, men plural. In a similar way, we can build chains, lists, trees, and circles of associations. A chain would be formed through the repetitive input of the strings of types such as a b, b c, c d, and so forth. A list would involve input strings of the form a b, a c, a d, a e, a f, where the word a is the list heading, and the other words are subordinate entries in the list. A tree would involve introducing the

18

strings $\underline{a\ b}$, $\underline{b\ c}$, $\underline{b\ d}$, $\underline{c\ e}$, $\underline{c\ f}$, $\underline{d\ g}$, $\underline{d\ h}$. Circular associations of the
form $\underline{a\ b}$, $\underline{b\ c}$, $\underline{c\ d}$, $\underline{d\ a}$ could also be formed. In fact, any particular
configuration of links is possible through the development of an appro-
priate set of input strings.

We have outlined one method for building a matrix of statistical
associations which has the general properties of being able to accept
and analyze unlimited amounts of natural language text dealing with a
wide range of topics. The potential uses of such a technique for form-
ing content association matrices are varied, each potential use depend-
ing on a number of further considerations. First, one must evaluate the
suitability of an association model to the problem area. Second, there
is the question of whether a statistical approach, rather than a deter-
ministic solution, is acceptable. Finally, there is the empirical con-
sideration of whether a matrix of content associations of this type is
powerful enough by itself to satisfy the needs implicit in any problem
at hand. The specific applications that we intend to explore are:
(1) message or document retrieval from a library of such messages or
documents, and (2) message or document dissemination or routing. We
are currently in the process of implementing a computer-based experi-
mental system for establishing and using the statistical association
matrix for message routing and retrieval along the lines suggested
above.

PROGRAMMING THE STATISTICAL ASSOCIATION TECHNIQUE

Input Program

As indicated previously, any natural language message material can serve as an input as long as it is in a form compatible with the input requirements of the computer. The input may consist of a complete message or document, message abstracts, titles, or key words and may be placed in the computer by any acceptable input device. At present, very few extensive documents or message files are in a form suitable for use as direct input; to make up a deck of punched cards for a book, for example, is a major effort. However, there are two types of inputs currently available that show promise: the teletypesetter paper tape used by the national magazine and newspapers for regional printing control and the paper tape output used by some document producing agencies for the same or similar purposes.[4]

For our initial efforts, a search was undertaken to locate suitable natural language corpora already in a computer-compatible form. Certain criteria of adequacy were: (1) representative of a heterogeneous message or document file; (2) pre-indexed so that criteria of retrieval success could be simply developed; (3) relatively recent; and (4) in a form convenient for input.

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[4]The reader is referred to Stevens (1961) for an excellent discussion of the types of texts available for use in experimental efforts. Cornelius (1961) discusses input problems in general and appears rather reluctant to place any hope on an input device short of an optical reading device.

We found that the Armed Services Technical Information Agency Technical Abstract Bulletin (ASTIA TAB) met these criteria. In addition, the TABs were already being printed from Remington Rand punched paper tapes. Arrangements were made through the Chief of the ASTIA Data Processing Branch and the Director of the Office of Technical Services, U. S. Department of Commerce to borrow the punched paper tapes for two TAB issues, 15 March and 1 April 1962. With the use of an IBM Paper tape reader, the TABs were transferred directly onto magnetic tape in a form compatible with the 1410 computer. Due to errors in the paper tape and certain incompatible character sets, the entire corpus had to be both hand and machine edited.

For those unfamiliar with ASTIA TABs, a typical abstract is given in Fig. 1. It should be noted that a great deal of information is provided for the reader and that many different types of system inputs therefore are available: author names, titles, descriptors, as well as an abstract.

For simplicity of present discussion, in the following material we will restrict the system input to the descriptor list, which we will call the descriptor string. All of the descriptors for a single document are treated as one long sentence of separate words in sequence. We do not maintain the actual descriptors separated by punctuation but use all of the individual words in the entire set of descriptor words as individual types in one long string. All punctuation and capitalization are ignored. (See Fig. 2.)

AD-269 587   Div. 12
(TISTA/SEB) OTS price $4.00

Space and Information Systems Div., North
American Aviation, Inc., Downey, Calif.
SPACE RADIATOR ANALYSIS AND DESIGN. PART I,
by D. B. Mackay and C. P. Bacha. Oct 61, 287p.
incl. illus. tables, refs. (Rept. no. SID 61-
66)
(Contract AF 33(616)7635, Proj. 6146)
(ASD TR 61-30, pt. 1) Unclassified report

  DESCRIPTORS: (Spaceships, Satellite vehicles,
  *Radiators, Radiant heating panels, Metal
  plates, Refrigerant condensers, Heat, Tempera-
  ture control, Heat transfer, Heat exchangers,
  Convection, *Thermal radiation, Design,
  Configuration, Effectiveness, Mathematical
  analysis, Military requirements.)

The thermal analysis of component elements of
space radiators is described. Elements include
rectangular and circular plates of uniform thick-
ness, triangular and trapezoidal fins, and con-
stant temperature-gradient fins. A complete
condenser and a radiator are analyzed and illus-
trative examples given. The thermal analyses
produced relationships between the physical prop-
erties and dimensions, element and environmental
temperatures, and rates of heat transfer. These
are shown graphically for all types of elements.
The optimum proportions of space radiator
elements having the greatest ratio of heat
radiation rate per pound of weight are also
indicated graphically, and procedures for their
calculation are shown. The discussions on con-
densers and radiators include dimensional-thermal
relationships and weight-optimizing procedures
for complete units. (Author)

Taken from ASTIA TAB, 15 March 1962.

Fig. 1 Typical ASTIA Abstract

269 507   C042   (●CARBON CIOXIDE, ●DECOMPOSITION, ●REDUCTION, HIGH TEMP
ERATURE RESEARCH, RADIA-TICN EFFECTS, PHOTOCHEMISTRY, ALKALI METALS, ALK
ALI METAL COMPOUNDS, HYDRIDES, HYDROGEN, CATALYSIS, CATALYSTS, IRON, WAT
ER, SEPARATION, CARBON DEPCSITS.)   (WATER, ELECTROLYSIS.) (SPACESHIPS, S
ATELLITE VEHICLES, ●AIR CCN-DITIONING EQUIPMENT, PRODUCTION, OXYGEN.)
   -

269 557   0043   (●HIGH PASS FILTERS, ●TELEPHONE COMMUNICATION SYSTEMS,
MULTICHANNEL TELEPHCNE SYSTEMS, CIRCUITS.) (PULSE TRANSMITTERS, PHASE M
ODULATION, ●SIGNAL-TO-NOISE RATIO.) (DATA TRANSMISSION SYSTEMS, TELEPHON
E LINES, TELEPHCNE SIGNALS, ATTENUATION.)   -
269 561   C044   (●TELEPHCNE COMMUNICATION SYS-TEMS, DIGITAL SYSTEMS, SW
ITCHING CIRCUITS, PANEL BCARDS (ELECTRICITY), MULTIPLEX TRANS-MISSION, S
TORAGE, CONTROL, CESIGN.)   (●MULTI-CHANNEL TELEPHONE SYSTEMS, DATA TRANS
MISSION SYSTEMS, ELECTRONIC SWITCHES, TIME INTERVAL COUNTERS, ●MAGNETIC
CORE SWITCHES.)   -
269 562   0045   (ENERGY, ●TRANSFORMERS, TRANS-DUCERS, ●ELECTROMECHANICA
L CONVERTERS, CIR-CUITS, ELECTRICAL NETWORKS.)   (N ON-LINEAR DIFFERENTI
AL EQUATICNS, LINEAR SYSTEMS.)   -
269 568   0046   (●INTEGRAL TRANSFORMS, INTEGRAL EQUATIONS, MATRIX ALGEB
RA, SPECTRCGRAPHIC ANALYSIS.) (RADIO SIGNALS, NOISE (RADIO), INFORMATIO
N THEORY.) THESES.   -
269 570   0047   (●LATTICES, THEORY, ●LIQUIDS, ●GASES, ●SOLIDS, ABSORPTI
ON, PHYSICAL PRCP-ERTIES.) (MOLECULES, PARTICLES, VELOCITY, DENSITY, EN
TROPY.) (●QUANTUM STATISTICS, PROBABILITY, INTEGRATION, STATISTICAL DI
STRIBUTION.)   -
269 574   0048   (●ELECTRIC DETONATORS, ●ELECTRIC IGNITERS, ELECTRIC BRI
DGES, TEMPERATURE, ELECTRCMAGNETIC EFFECTS, ELECTRIC WIRE, HAZARDS, DETE
CTORS, CPTICAL EQUIPMENT, ●TEMPER-ATURE WARNING SYSTEMS, DESIGN, SENSITI
VITY, TESTS.)   -
269 577   0049   (●BUCYANT MATERIALS, ●PROTECTIVE CLOTHING, TERMINAL BAL
LISTICS.) (FIBERS, SYNTHETIC FIBERS, TEXTILES, ●DACRON, ●ORLON, ●NYLON,
RESINS, ACRYLIC RESINS, FLCTATICN, CLEANING.) (FRAGMENTATION, PENETRAT
ION, TESTS.) (●BCCY ARMOR, MATERIALS.)   -
269 583   C050   (●ATOMIC SPECTRUM, ●ELECTRIC FIELDS, ●INFRARED SPECTROS
COPY, ●MOLECULES.) (DIPOLE MOMENTS, POLARIZATION, QUANTUM MECHANICS, ENE
RGY.) (OPTICS, LIGHT TRANSMIS-SION, OPTICAL EQUIPMENT, MOLECULAR BEAMS.
) (COATINGS OF ALUMINUM, CHROMIUM, GOLD.) (REFLECTION, DIFFRACTION. GRATI
NGS, CCLLIMATCRS.).   -
269 584   0051   (LIQUID RCCKET PROPELLANTS, ●PROPELLANT TANKS, PRESSUR
E, CCNFIGURATICN, GECMETRY, VCLUME, DESIGN, MILITARY REQUIRE-MENTS, MATH
EMATICAL ANALYSIS, HANDBOCKS.) (GAS GENERATING SYSTEMS, ROCKET FUELS, RO
CKET CXIDIZERS, VAPORIZATICN, COMBUSTION.) (GASES, LIQUEFIED GASES, OXYG
EN, HYDROGEN, HYDRAZINES, METHYL HYDRAZINES, NITROGEN COM-POUNDS, TETROX
IDES, STORAGE.) (PROPELLANT TANK LINERS, MATERIALS, METALS, PHYSICAL P
ROPERTIES.) HEAT EXCHANGERS.   -
269 587   0052   (SPACESHIPS, SATELLITE VEHICLES, ●RADIATORS, RADIANT HE
ATING PANELS, METAL PLATES, REFRIGERANT CONDENSERS, HEAT, TEMPERA-TURE C
CNTRCL, HEAT TRANSFER, HEAT EXCHANGERS, CONVECTION, ●THERMAL RADIATION,
DESIGN, CONFIGURATION, EFFECTIVENESS, MATHEMATICAL ANALYSIS, MILITARY RE
QUIREMENTS.)   -
269 589   0053   (●GRCUP DYNAMICS, ●JOB ANALYSIS, EFFECTIVENESS, FEEDBAC
K, LABOR.) SOCICMETRICS. MATHEMATICAL ANALYSIS.   -

Fig. 2 A Sample of the Descriptor Strings. (The First Two
Groups of Numbers Are the AD Number)

Frequency Matrix Formulation Program

The frequency matrix formulation program converts the input described above into a matrix of word pair co-occurrences suitable for use in the association matrix program. The program[5] actually is made up of several distinct subroutines. The subroutines and the machines for which they are written are listed:

(1) Packing subroutine - IBM 1410 computer

(2) Concordance subroutine - IBM 7090 computer

(3) Pairing subroutine - IBM 7090 computer

(4) Sorting subroutine - IBM 7090 computer

(5) Counting subroutine - IBM 7090 computer

(6) Printing subroutine (optional) - IBM 1410 computer.

Although the specific functions of these subroutines are suggested by their names, a quick summary of what they do may be informative.

(a) Packing. To edit input material expeditiously, an editing program was used. However, the edited output to the concordance subroutine was not adequate. That is, the tape record lengths are small (72 characters) while the concordance can handle up to 1000-character record-lengths. Thus, to provide the input in a more efficient format, a packing subroutine was written whose output results in 1000-character record-lengths.

(b) Concordance. This subroutine accepts the output of the packing subroutine and writes a tape which adds for each word a series of identifying numbers. Each word is thus identified as having come from a particular message, a particular sentence, and a particular position in that sentence. The concordance tape is never erased since it contains the entire corpus. The tape is used for several purposes. It is used

_____

[5]All of the subroutines in this program were written by members of the Programming Research Subdepartment of the Computer Applications Department at MITRE. In addition, members of this group aided in the conceptualization of much of this work.

during the retrieval program in order to assign document relevancy numbers to each document sentence, and it can also be used at a later time with different programs to generate statistical information about various linguistic parameters such as word length, sentence length, word distances, and the like, as desired.

(c) Pairing. This subroutine works interwoven with the concordance subroutine although they are independent of each other. It is initiated by the discovery of an end-of-sentence mark. The function of this routine is to pair words and prepare an output in the form: "Word - Word" for every word in the string. For example, if the input sentence were "270 563 Algebraic topology groups mathematics."[6] - the subroutine would write:

algebraic - topology

topology - algebraic

algebraic - groups

groups - algebraic

algebraic - mathematics

mathematics - algebraic

topology - groups

groups - topology

topology - mathematics

mathematics - topology

groups - mathematics

mathematics - groups

(d) Sorting. In order to count the number of common word pairs, all the word-pairs must be put into some cogent order. This is the most time-consuming portion of the entire program and perhaps most basic to it. The alphabetizing of the word pairs is done by the IBM - 9 SORT program.

(e) Counting. The list of alphabetized word pairs is then reviewed and identical word pairs counted and combined.

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[6] ASTIA AD 270 563, 1 April 1962

(f) <u>Printing</u>. The printing subroutine is optional and when the system is checked out and operable it will rarely be used. At present, however, for checkout purposes, printouts of the frequency matrix formulation program are being made (see Fig. 3).

Statistical Language Information

At present, we have not prepared a detailed program to provide statistical language information. However, certain parameters essential to the operation of the present program are computed and can be printed out at relatively small time and computer cost. These are:

(a) Number of Tokens

(b) Number of Types

(c) Number of Strings

(d) Frequency Distribution of string lengths in steps of 1 from 1 to 50.

Other linguistic information can, of course, be obtained from the concordance tape.

Association Matrix Program

The word-word association matrix uses the output of the frequency matrix generation program. The cell values resulting from the normalization subroutines of the association matrix represent the degree of association between two words after certain corpus artifacts are removed. As we noted in our previous discussion, a cell value in the original frequency matrix is affected by three artifacts; the number of times a word appears in the corpus, the length of the corpus; and, the average string lengths. Other variables probably tend to affect a frequency

Fig. 3   A Sample of the Frequency Matrix for the Query Term "CONVECTION"

ANALYSIS	1 BOUNDARY	2 CHEMICAL	1 COMBUSTION	1
CONDENSERS	1 CONFIGURATION	1 CONTROL	1 DATA	1
DESIGN	1 DIFFUSION	1 DISSOCIATION	1 EFFECTIVENESS	1
EXCHANGERS	1 EXPERIMENTAL	1 FLOW	3 GAS	2
HEAT	4 HEATING	1 HYDROGEN	1 HYPERSONIC	2
LAYER	2 MATHEMATICAL	1 METAL	1 MILITARY	1
MOTORS	1 NOZZLES	1 OXYGEN	1 PANELS	1
PLATES	1 PROPERTIES	1 RADIANT	1 RADIATION	1
RADIATORS	1 REACTIONS	2 RECOMBINATION	1 REFRIGERANT	1
REQUIREMENTS	1 ROCKET	1 SATELLITE	1 SPACESHIPS	1
TABLES	1 TEMPERATURE	1 THERMAL	1 THERMOCHEMISTRY	1
THERMODYNAMICS	1 TRANSFER	2 TRANSPORT	1 VEHICLES	1

Fig. 4   A Sample of the Association Matrix for the Query Term "CONVECTION"

ANALYSIS	+0000 BOUNDARY	+0013 CHEMICAL	+0005 COMBUSTION	+0006
CONDENSERS	+0007 CONFIGURATION	+0006 CONTROL	+0035 DATA	+0004
DESIGN	+0003 DIFFUSION	+0006 DISSOCIATION	+0006 EFFECTIVENESS	+0006
EXCHANGERS	+0006 EXPERIMENTAL	+0006 FLOW	+0020 GAS	+0013
HEAT	+0025 HEATING	+0006 HYDROGEN	+0006 HYPERSONIC	+0014
LAYER	+0013 MATHEMATICAL	+0004 METAL	+0006 MILITARY	+0006
MOTORS	+0006 NOZZLES	+0006 OXYGEN	+0006 PANELS	+0007
PLATES	+0007 PROPERTIES	+0001 RADIANT	+0007 RADIATION	+0004
RADIATORS	+0007 REACTIONS	+0013 RECOMBINATION	+0007 REFRIGERANT	+0007
REQUIREMENTS	+0007 ROCKET	+0004 SATELLITE	+0006 SPACESHIPS	+0006
TABLES	+0006 TEMPERATURE	+0003 THERMAL	+0005 THERMOCHEMISTRY	+0007
THERMODYNAMICS	+0006 TRANSFER	+0013 TRANSPORT	+0006 VEHICLES	+0005

matrix cell value but these cannot, at this time, be fully accounted for and thus subtracted from the cell value.

The normalization program includes an optional printout routine for the 1410 computer (see Fig. 4). As with other optional printout routines, we do not expect it to be used after checkout is completed. However, this routine is useful when we deliberately alter cell values by adding special word strings to strengthen specific word associations.

An Algorithm for Routing or Retrieval

We start with any set of query or routing types, all of which must appear at least once in the corpus. These types serve as the means by which we expand to another set of types, all of which are highly associated through the normalized matrix to the original query types taken as a whole. This set of associated types, combined with the original set of query types, then serves as the basis for deriving another set of types. The procedure can, of course, be repeated any number of times.

This informal characterization of the algorithm can be stated more precisely: Given a set of query types, the matrix is searched to locate all types which have been associated with each and every one of the query types in the set. From this group of words, those (equal in number to the number of query types) that have the highest sum of normalized matrix weights (when summed over all of the query types) are selected to form a set of first order types.

Having obtained this set of first order associates, we form a new set combining these first order types with the original query types. With this larger set of joint first order and query types, the matrix again is searched to locate all types that have been associated with each and every one of the types in this expanded set. From this newly located group of types, those (equal in number to the number of joint first order and query types) that have the highest sum of normalized matrix weights (when summed over all of the first order plus query types) now are selected to form a set of second order types.

The procedure for determining first order associates can be presented in a symbolic form as follows:

Let α_{jk} = the Z'_{jk} for τ_j with respect to q_k

where, $q \in Q$

$Q = \{$query terms$\}$

τ_j is any term in the normalized matrix but $\notin Q$

j = any row of the normalized matrix

k = any column of the normalized matrix

then $\tau_j \in A \equiv (k) \, \alpha_{jk}$ & s_j is among the n_q highest sum

where, $A = \{$first order associates$\}$

$$s_j = \sum_{k=1}^{n_q} \alpha_{jk}$$

n_q = the number of terms in the class Q

The second order associates are derived in a similar fashion as follows:

Let β_{jk} = the Z'_{jk} for τ_j with respect to a_k

where, a ϵ A

τ_j = any term in the normalized matrix but $\notin Q \notin A$,

then $\tau_j \epsilon B \equiv (k) \; \alpha_{jk} \; \beta_{jk}$ & s'_j is among the $2n_q$ highest sums

where, B = {second order associates}

$$s'_j = \sum_{k=1}^{n_q} \alpha_{jk} + \sum_{k=1}^{n_a} \beta_{jk}$$

n_a = the number of terms in the class A.

From the above it follows that Q, Z, B are mutually exclusive.

Having derived the first and second order association terms we can then note for each document the occurrence of each query term, each first order term, and each second order term. The documents then are ordered according to the following rules and definitions:

Let n_b = the number of terms in the class B (2nd order associates)

$n_q = n_a = n_b/2$

$j = n_q + n_a + n_b$

$k = 100n_q + 10n_a + n_b$

$D_{j,k}$ = a message or document with j and k indices as defined above.

$D_1 r > D_2$ means that D_1 is more relevant than D_2.

The ordering of messages or documents on the basis of relevance is
then:

$$D_j r > D_{j-1}$$

and within the j set of messages

$$D_{j,k} r > D_{j,k-1}$$

In such an ordering each cut "j" is further subdivided by "k ."

This procedure, of course, presumes that messages containing the query
types are more relevant than those that do not, those that contain first
order associates are more relevant than those that do not, and so forth.

Let us now examine a specific example. We derive the association
matrix in the manner described above for 500 documents as represented
by their ASTIA descriptors, and a printout is obtained.

The query types chosen (Q) are thermal, radiation, convection. We
then search for those other types that are associated, either negatively
or positively, with all three of them. Fig. 5 gives the more highly as-
sociated types and their values as determined from the association ma-
trix, as well as their algebraic sum. Based upon the rules listed above,
we select the three first-order associate terms (Class A) that have the
highest algebraic sum but that also satisfy the requirement of mutual exclu-
sion. Radiation and thermal are highest with values of 365 and 157,
respectively. However, they already have been chosen as query terms and
therefore are rejected. The next three highest are heat with 133,
temperature with 115, and transfer with 107.

Associated Terms	Query Terms			Algebraic Sum
	Radiation	Thermal	Convection	
radiation	245	116	4	365
thermal	116	36	5	157
heat	8	100	25	133
temperature	87	25	3	115
transfer	28	66	13	107
combustion	39	20	6	65
spaceships	39	7	6	52
mathematical	15	14	4	33
panels	16	3	7	26
control	17	2	5	24
heating	5	11	6	22
radiant	6	6	7	19
radiators	6	6	7	19
refrigerant	6	6	7	19

(Summed over the three query terms; the cell weight is Z' as previously defined in the paper; each Z' has been multiplied by 1×10^8.)

Fig. 5 High First-Order Associations Ordered by Algebraic Sum

Now having six terms, we then search for all of the words that are associates of all the six taken as a group, and obtain their algebraic sums. Fig. 6 gives the types most highly associated with all six terms. The six second-order associates with the highest sum are chosen by a process similar to the one for the first order associates, terms previously chosen being eliminated. In the order of their algebraic sum, these are heating (195), gas (148), boundary (140), layer (140) exchangers (99), and in this case because of the tie in value, hydrogen and spaceships both with (67).

Having obtained the first and second order association types, we then determine the number of Q, A, and B terms each document contains. In other words, we develop the j index value for each document. If any term is repeated within the document, it is recorded only once. Those documents that have a higher j should be more relevant than those having a lower j. However, for some js the number of documents is quite large, and it is necessary to use the k index within each j. Fig. 7 shows in rank order the documents retrieved by this procedure for the query: thermal, radiation, convection in terms of j, and k within j, with a cut-off point at j=3.

The selection and ordering of the documents shown in Fig. 7 have a high degree of face validity; however there is another side to this coin: the number of relevant documents that were not retrieved by the algorithm. The authors and their staff rated all 500 documents on the

word	Query Terms			First Order Terms			Algebraic Sum
	radia-tion	ther-mal	convec-tion	heat	tempera-ture	transfer	
heat	8	100	25	110	131	214	588
radiation	245	116	4	8	87	28	488
transfer	28	66	13	214	12	20	353
thermal	116	36	5	100	25	66	348
temperature	87	25	3	131	-41	12	217
heating	5	11	6	78	44	51	195
gas	-27	22	13	103	-0	37	148
boundary	-7	5	13	73	-3	59	140
layer	-7	5	13	73	-3	59	140
exchangers	0	10	6	62	2	19	99
hydrogen	-10	11	6	32	13	15	67
spaceships	39	7	6	4	9	2	67
panels	16	3	7	21	5	5	57
radiant	6	6	7	20	5	6	50
radiators	6	6	7	20	5	6	50
refrigerant	6	6	7	20	5	6	50

(Summed over all query and first order terms; the cell weight is Z' as previously defined; each Z' has been multiplied by 1×10^8.)

Fig. 6 High Second-Order Associations Ordered by Algebraic Sum

34

basis of their relevance to the query <u>thermal</u>, <u>radiation</u>, <u>convection</u>.
The judgment of relevance was made on the basis of the more complete
document abstract rather than on the descriptor string. Seven addi-
tional relevant documents were located. Of these, two were selected
by the algorithm with a cut-off point set at j=2 and one was picked
up with j=1. The remaining four were poorly indexed and would have
been judged not relevant by a human who depended upon the descriptor
string only, as the matrix did, rather than upon review of the abstracts.

Conclusion

The work done to date, and reported at this time is introductory.
Continuing analysis of statistical association procedures is now in
progress, and additional results will be presented in subsequent re-
ports.

AD-269 587   Div. 12
(TISTA/SEB) OTS price $4.00

Space and Information Systems Div., North
American Aviation, Inc., Downey, Calif.
SPACE RADIATOR ANALYSIS AND DESIGN. PART I,
by D. B. Mackay and C. P. Bacha. Oct 61, 287p.
incl. illus. tables, refs. (Rept. no. SID 61-
66)
(Contract AF 33(616)7635, Proj. 6146)
(ASD TR 61-30, pt. 1) Unclassified report

DESCRIPTORS: (Spaceships, Satellite vehicles,
*Radiators, Radiant heating panels, Metal
plates, Refrigerant condensers, Heat, Tempera-
ture control, Heat transfer, Heat exchangers,
Convection, *Thermal radiation, Design,
Configuration, Effectiveness, Mathematical
analysis, Military requirements.)

The thermal analysis of component elements of
space radiators is described. Elements include
rectangular and circular plates of uniform thick-
ness, triangular and trapezoidal fins, and con-
stant temperature-gradient fins. A complete
condenser and a radiator are analyzed and illus-
trative examples given. The thermal analyses
produced relationships between the physical prop-
erties and dimensions, element and environmental
temperatures, and rates of heat transfer. These
are shown graphically for all types of elements.
The optimum proportions of space radiator
elements having the greatest ratio of heat
radiation rate per pound of weight are also
indicated graphically, and procedures for their
calculation are shown. The discussions on con-
densers and radiators include dimensional-thermal
relationships and weight-optimizing procedures
for complete units. (Author)

j = 9
k = 333

AD-269 741   Div. 9, 25, 12
(TISTA/VGW) OTS price $3.60

Space Technology Labs., Inc., Los Angeles, Calif.
RADIATION FROM SHOCK-HEATED AIR. PART I.
EQUILIBRIUM RADIATION,
by Hans G. Myer. Oct 61, 33p. incl. illus.
8 refs. (Rept. no. 6130-0001-NU-P01)
(Contract AF 04(694)1)
(BSD TN 61-21)   Unclassified report

DESCRIPTORS: (Re-entry vehicles, Shock tubes,
*Shock waves, Boundary layer, Re-entry aero-
dynamics, Aerodynamic heating, *Thermal
radiation, *Heat transfer, Numerical analysis,
Temperature, Density, Mathematical prediction.)

A computational procedure giving equilibrium
radiative heat transfer rates to the surface of
a shock engulfed vehicle is presented. The local
transfer rates are obtained in terms of the local
temperature and density at the outer edge of the
boundary layer and an effective thermal layer.
The computed radiative transfer rates around a
typical entry vehicle are presented. A computa-
tional procedure for the non-equilibrium ra-
diation is presented in Part II. (Author)

j = 8
k = 233

Fig. 7 Rank Order of Documents Retrieved

AD-269 816   Div. 25, 9, 4
(TISTP/MFA) OTS price $10.10

AeroChem Research Labs., Inc., Princeton, N. J.
CONVECTIVE HEAT TRANSFER WITH CHEMICAL REACTION.
I. THEORETICAL DEVELOPMENT OF CORRELATION FOR-
MULAE FOR THE PREDICTION OF HEAT FLUXES IN HIGH
PERFORMANCE ROCKET MOTORS AND RELATED SYSTEMS.
Interim technical rept. on Research on Combus-
tion Kinetics,
by Daniel E. Rosner. Aug 61, 123p. incl. illus.
tables, 129 refs.
(Contract AF 33(616)6216, Proj. no. 7013)
(ARL 99, pt. 1)
                              Unclassified report

DESCRIPTORS: (*Heat transfer, *Convection,
Boundary layer, Gas flow, Chemical reactions,
Thermochemistry, Thermodynamics, Rocket
motors.) (Transport properties, Recombination
reactions, Boundary layer, Gas flow, Hyper-
sonic flow, Hypersonic nozzles.) (Dissocia-
tion, Combustion, Hydrogen, Oxygen, Diffusion.)
(Experimental data, Tables.)

Energy transfer in chemically reacting boundary
layer flows is discussed from the point of view
of the investigator, who is seeking to extend
existing correlation formulae to cases in which
thermochemical effects influence heat transfer
rates. Emphasis is placed on the prediction of
convective heat fluxes in high performance
rocket motors; however, examples are also taken
from the field of hypersonic gas dynamics, as
follows: the appropriate driving force for heat
transfer with chemical reaction, effects of the
enhanced efficiency of energy transport by diffu-
sion as compared to ordinary conduction, calcula-
tion of the turbulent film conductance in axisym-
metric nozzles, thermodynamic calculation of
enthalpy/mixture-ratio charts for combustion gas
mixtures, effects of chemical non-equilibrium
in the gas phase, effects of surface catalyzed
exothermic recombination reactions, estimation
of transport properties in partially dissociated
gas mixtures with emphasis on the binary diffu-
sion coefficients pertaining to molecular frag-
ments. (Author)

j = 7
k = 124

AD-269 797   Div. 25
(TISTP/TL) OTS price $2.60

AVCO Research Lab., Everett, Mass.
BASIC STUDIES IN MAGNETOHYDRODYNAMICS.
Final rept., 1 May 57-31 Oct 61,
by Richard M. Patrick. 31 Oct 61, 28p. incl.
illus. 17 refs.
(Contract AF 49(638)61, Proj. 9751)
(AFOSR-1782)   Unclassified report

DESCRIPTORS: (*Magnetohydrodynamics, Gas flow,
*Magnetic fields, *Configuration, Drag, Lift,
Electron beams, Electron guns, Hydrogen,
Argon.) (*Plasma physics, Propulsion, Gas
ionisation, Exhaust gases, Velocity, Rockets,
Heating, Specific impulse.) (*High tempera-
ture research, Shock tubes, Thermonuclear reac-
tions, Electric power production, Heat ex-
changers, Infrared detectors, Measurement,
Heat transfer, Shock waves.)

Research was directed toward obtaining a basic
understanding of magnetohydrodynamics. The
initial studies led to three possible applica-
tions for magnetohydrodynamics which in turn led
to three categories of research. The first
application appeared in connection with the prob-
lem of high-altitude, very high velocity flight
which we call fight magnetohydrodynamics. The
second application was plasma propulsion. The
third category was the production of a very high
temperature collision-free plasma. (Author)

j = 7
k = 034

Fig. 7 (Continued)

AD-269 195   Div. 10
(TISTA/SEH) OTS price $7.60

Beech Aircraft Corp., Boulder, Colo.
ESTABLISHING PROVEN DESIGN CRITERIA FOR CRYOGENIC

BOOST TANKS.
Quarterly progress rept. no. 8 for period ending
31 July 61,
by J. G. Connelly and B. R. Etheridge. Dec 61,
39p. incl. illus. 2 refs.
(Contract AF 33(616)5154, Proj. 3084)
(DGRP TR-61-2)   Unclassified report

    DESCRIPTORS: (Liquid rocket propellants,
    Cryogenics, *Propellant tanks, Fuel tanks,
    Propellant tank liners, Insulating materials,
    Design, Processing, Heat transfer, Aerodynamic
    heating, Test methods, Test equipment.) (Liq-
    uefied gases, Hydrogen.) Thermal insulation.

The design and fabrication of two 7000 gal
liquid hydrogen fuel tanks of Ti and stainless
steel are described. Insulating materials and
methods of insulation are also described. Tests
were successfully conducted to check out the
tank drain assembly. Further tests will be con-
ducted to determine the heat transfer of the
tanks during simulated rocket flight conditions.

j = 5
k = 122

AD-269 247   Div. 9, 25
(TISTP/JW) OTS price $3.60

Instrumentation Lab., Mass. Inst. of Tech.,
Cambridge.
GYRO TEMPERATURE CONTROL WITH A LIQUID SOURCE,
by R. E. Marshall and R. W. Jonsson. Mar 60,
34p. incl. illus. tables, 6 refs. (Rept. no.
E-906)
(Contract AF 04(647)303)
                    Unclassified report

    DESCRIPTORS: (Liquids, Heat transfer, *Gim-
    bals, Temperature control, *Gyroscopes.)
    (Boundary layer, Fluid flow, Heat, Heat trans-
    fer, Test methods.)

The thermal and fluid conditions that exist in
the test gimbal and fluid jacket are described.
Fluid flow rates in the fluid jacket closely
govern the gyro heat transfer performance and
improvements in this flow rate will substantially
raise this performance. Coupled to this is the
close attention that must be paid to all heat
transfer parameters about the Test Gimbal,
evidenced by the changes in the surrounding
insulation. Several improvements are needed to
yield test conditions that fully simulate sys-
tem conditions. Notable ambient sensitivities
are still present in the test unit. Fluid tem-
perature loss-gain profiles, shows that the
thermal conduction losses of the gyro mountings
are great enough to prevent any fluid temperature
gain with power on. This situation can be cor-
rected by installing small auxiliary heaters on
the gyro mounting blocks to make up for these
conduction losses. The second correctable con-
dition involves the temperature controller sen-
sitivities and time constants. Experience has
shown that these factors are not in line with
similar types of control units. Only with a
precise description of all the thermal conditions
in both the laboratory test unit and the system
can the required accuracies of gyro instruments
be realized in operational systems. (Author)

j = 5
k = 032

Fig. 7 (Continued)

38

Boeing Scientific Research Labs., Seattle, Wash.
EFFECT OF SLIP ON THE LAMINAR BOUNDARY LAYER
NEAR THE LEADING EDGE OF A FLAT PLATE IN HYPER-
SONIC RAREFIED GAS FLOW,
by Robert E. Street. Nov 61, 64p. incl. illus.
(Rept. no. 49; D1-82-0138)
Unclassified report

DESCRIPTORS: (Sheets, Gas flow, Aerodynamics,
*Hypersonics, *Superaerodynamics, Shock waves,
Boundary layer, *Laminar boundary layer,

Friction, Drag, Heat transfer, Mathematical
analysis, Differential equations, Partial
differential equations, Integral equations,
Series.)

Near the leading edge of a sharp flat plate in
high speed, low density flow of high temperature
gases the induced shock wave is almost straight
and the pressure and velocity downstream are
therefore approximately constant. Assuming that
the outer edge of the viscous layer coincides
with the shock wave in this region of the flow,
it is possible to integrate the boundary layer
equations with first order slip in the boundary
conditions at the plate using a Gortler-type
series in fractional powers of x, the longitud-
inal distance along the plate. The first two
terms in this series have been found in closed,
analytical form. To terms in x to the first
power the result leads to a constant value of the
skin friction coefficient and heat transfer
coefficient. As an example the result is applied
to a flat plate flying at Mach number 20 at
295,000 feet altitude, where the effects of slip
are significant for a considerable distance
downstream of the leading edge. (Author)

j = 5
k = 023

Lockheed Aircraft Corp., Marietta, Ga.
SURVEY AND ANALYSIS OF HYPERSONIC AND RE-ENTRY
VEHICLES.
Rept. on Research on Aerodynamic Flow Fields,
by R. H. Lange, B. H. Little, Jr. and others.
Sep 61, 113p. incl. illus. 521 refs.
(Contract AF 33(616)7237, Proj. 7064)
(ARL-62)   Unclassified report

DESCRIPTORS: (*Re-entry vehicles, *Hyper-
velocity vehicles, Flight paths, Shock waves,
Re-entry aerodynamics, Superaerodynamics,
*Hypersonics, Ablation, Boundary layer,
*Aerodynamic heating, Friction, Heat transfer,
Lift, Drag, Pressure, Theory, Mathematical
analysis.) *Bibliography.

A survey and analysis was made of the aerother-
modynamic problem areas in the flight spectrum
of hypersonic glide and re-entry vehicles. This
flight spectrum was defined by speeds between
5000 ft/sec and orbital speed and by altitudes
between 100,000 and 400,000 feet. Major problem
areas of flight within this spectrum were ana-
lyzed to determine the coverage of existing data
and to recommend areas where further research is
needed. (Author)

j = 5
k = 023

Fig. 7 (Continued)

Brown U., Providence, R. I.
EFFECTS OF CONDUCTION AND VISCOSITY ON THE
STABILITY OF LAMINAR FLAME,
by J. Y. Parlange and Boa-Teh Chu. Sep 61,
19p. 5 refs. (Rept. no. AF 646/3)
(Contract AF 49(638)646, Proj. 9751)
(AFOSR-1594)
Unclassified report

DESCRIPTORS: (*Laminar boundary layer,
*Flames, Conductivity, Viscosity, Stability,
*Fluid flow, Gases, Exhaust gases, Mach
number.) (Gas ionization, Chemical reactions,
Temperature, Heat, Specific heat, Pressure.)
(Molecular structure, Theory, Gases, Liquids.)
(Perturbation theory, Equations, Differential
equations, Partial differential equations.)

The effects of conduction and viscosity on the
stability of laminar flame are examined. If
L denotes the ratio of the wave length of a
disturbance to the flame width and alpha is the
ratio of the ultimate temperature of the burned
gas to the initial temperature of the fresh
mixture, the flame is found to be stable if L
is less than (or equal to) 2 alpha/(alpha-1)
multiplied by 1/RePr where Re is the Reynolds
number of the flame based on the flame width
and Pr denotes the Prandtl number of the mixture.
It is further shown that the stabilization is
achieved primarily through the effect of heat
conduction on the flame speed rather than the
influence of viscosity. (Author)

$$j = 5$$
$$k = 023$$

Fuels Research Lab., Mass. Inst. of Tech.,
Cambridge.
TRANSIENT HEAT AND MOISTURE TRANSFER TO SKIN
THROUGH THERMALLY IRRADIATED CLOTH,
by H. C. Hottel, G. C. Williams and others,
26 Dec 61, 138p. incl. illus. 23 refs. (Tech-
nical rept. no. 8)
(Contract DA 19-129-qm-1592, Proj. nos. 7-12-01-
002c and 7-99-01-001)
Unclassified report

DESCRIPTORS: (*Skin, Burns, Inhibition, Sim-
ulation.) (Protective coverings, *Protective
clothing, Fire protective clothing, Materials,
Textiles, Cotton textiles, *Heat transfer,
Thermal conductivity, Colors, Moisture, Math-
ematical analysis.) (Thermal radiation, Ther-
mal insulation, Test methods, Test equipment.)

A study was made of the action of cloth in pro-
tecting skin from thermal injury resulting from
exposure to high-intensity thermal radiation.
Methods were developed to obtain temperature-
time-depth data for a system simulating skin
covered by a layer of dry or moist cloth. Ex-
perimentally this was accomplished by the use of
a copper-air simulant which accepts heat at the
same rate as human skin but develops a propor-
tionally stretched temperature profile. The
method facilitates the inspection of the influ-
ences on temperature distribution in the skin of
various system properties and the surrounding
conditions. The skin enthalpy rise above a
critical temperature level, a feasible basis for
correlating burn data, was found to be very sen-
sitive to slight variations in the temperature
response and deserves further testing. (Author)

$$j = 4$$
$$k = 220$$

Fig. 7 (Continued)

40

AD-269.784   Div. 17, 25
(TISTN/BRW) OTS price $1.25

Defense Metals Information Center, Columbus, Ohio.
THE EMITTANCE OF CHROMIUM, COLUMBIUM, MOLYBDENUM, TANTALUM, AND TUNGSTEN,
by W. D. Wood, H. W. Deem, and C. F. Lucks.
10 Dec 61, 47p. incl. illus. 24 refs.
(DMIC Memo. no. 141)
Unclassified report

DESCRIPTORS: (Metals and Alloys of *Chromium, *Molybdenum, *Niobium, *Tantalum, *Tungsten.) (*Thermal radiation, Thermionic emission, Blackbody radiation, Heat transfer, Monochromatic light, Absorption, Brightness, Reflection.) (Test equipment, Thermocouples, Thermopiles, Optical equipment, Radiation pyrometers, Spectrophotometers, Thermistors.) Data,Tables.

A compilation is presented of original test data on emittance, reflectance, and adsorptance of Cr, Nb, Mo, Ta, and W. The data were taken from the literature published during the period 1940-1959 inclusive, and as much of the 1960 literature as could be obtained. The following sources were searched: Chemical Abstracts, Ceramic Abstracts, Metallurgical Abstracts, Nuclear Science Abstracts, and the files of the Defense Metals Information Center (DMIC). An attempt was made to evaluate these sources of data according to the apparent thoroughness of methods and techniques as described by the various investigators. In many cases the descriptions in the literature are a summary of methods and results, and a complete evaluation is impossible. Curves are presented which appear to indicate the most probable values for the various conditions and materials. (Author.)

j= 4

k= 220

AD-269 499   Div. 25
(TISTA/WAW) OTS price $6.60

Arnold Engineering Development Center, Arnold Air Force Station, Tenn.
DIAGNOSTICS OF A PLASMA FLAME EXHAUSTING TO ATMOSPHERIC PRESSURE,
by W. K. McGregor, Jr., M. T. Dooley, and L. E. Brewer. Jan 62, 65p. incl. illus. tables (AEDC TR 61-16)
(Contract AF 40(600)800, Proj. 8951)
Unclassified report

DESCRIPTORS: (Plasma physics, *Plasma jets, Gas ionization, Helium, *Argon, Temperature, Measurement, Instrumentation, Spectrographic analysis.) (Plasma jets, Exhaust gases, Exhaust flames, Thermal radiation, Mathematical analysis.)

A spectrometric method to measure temperature in a high temperature gas stream produced by a Gerdien-type arc plasma generator was developed. The Fowler-Milne peaking function method was employed which utilized both the spectral line and continuum radiation in the 4000 A range from an argon plasma. Excitation temperatures measured from line radiation and electron temperatures determined from the continuum radiation agreed within about five percent. The method was applicable provided temperatures larger than 16,000 K existed at the center of the axisymmetric jet; the range of temperature measurement was then from about 7000 to 28,000 K. Comparison of the average temperature obtained using the spectrometric method with the average temperature obtained using an energy balance indicated serious disagreement. Comparison of the total enthalpy obtained using the spectral temperature with that obtained from the energy balance also indicated disagreement. The reason for the disagreement was that the jet consisted of high frequency arc channels moving about in the stream and that the radiant emission resulted from these high temperature electrons rather than from the average gas atoms. (Author)

j= 4

k= 211

Fig. 7 (Continued)

AD-269 850   Div. 9
(TISTP/TL) OTS price $4.60

Geneynamics/Convair, San Diego, Calif.
EXPERIMENTAL DETERMINATION OF THE SLOW NO DECOM-
POSITION REGIME AROUND 3000 DEGREES K BEHIND
SHOCK WAVES.
by C. B. Ludwig, K. G. P. Sulzmann, and
P. S. Hrbacek. 30 June 61, 37p. incl. illus.
10 refs. (Rept. no. ZPh-110)
(Contract DA 04-495-ORD-3112)
(ARPA Order no. 39-59)   Unclassified report

   DESCRIPTORS: (*Shock waves, *Nitrogen com-
   pounds, *Oxides, *Infrared radiation, Velocity,
   Measurement, Temperature, Density, Optical
   systems.) (Heat transfer, Gages, Load distri-
   bution, Mach number, Vacuum systems, Photo-
   graphic analysis.) (Electronic equipment,
   *Shock tubes, Oscillograms, Oscilloscopes,
   Miniature electronic equipment, Piezoelectric
   gages.)

The decomposition of nitric oxide between 2250
and 3450 K has been studied in shock tube ex-
periments. The emitted infrared radiation of the
fundamental band system of NO has been used to
determine the time duration of the slow decom-
position regime of NO behind shock waves in pure
NO. It is found that the temperature dependency
of the duration is in good agreement with the
theoretical model we have described previously.
(Author)

j = 4
k = 130

AD-269 035   Div. 2, 30
(TISTP/MFA) OTS price $2.60

Air Force Cambridge Research Labs., Bedford,
Mass.
A NUMERICAL METHOD FOR COMPUTING RADIATIVE
TEMPERATURE CHANGES NEAR THE EARTH'S SURFACE.
by William P. Elliott and Donald W. Stevens.
Sep 61, 21p. incl. illus. table, 12 refs.
(GRD Research notes no. 69; AFCRL-869)
(Proj. 7655)
                    Unclassified report

   DESCRIPTORS: (Numerical analysis, *Infrared
   radiation, Earth, Surface properties.)
   (Temperature, Atmosphere, *Climate, Water
   vapor, Specific heat, Air, Density, Fog.)
   (Digital computers, Programming, Partial
   differential equations.)

A method of computing the temperature changes due
to infrared radiation flux divergence is
presented. The method is based upon a tabular
scheme developed by D. L. Brooks (J. Meteor.
7:313-321, 1950). Application of the method
to actual data shows that the radiative temper-
ature changes can exceed the observed temper-
ature changes at night. The radiative temper-
ature changes decrease with elevation and be-
come 1 - 2 degrees per day at about 100 meters.
Several applications of the method in boundary
layer studies are also indicated. (Author)

j = 4
k = 121

Fig. 7 (Continued)

42

Westinghouse Electric Corp., Pittsburgh, Pa.
DESIGN OF MODEL OF A THERMOELECTRIC AIR CON-
DITIONING SYSTEM FOR SUBMARINES.
Final rept., 1 June 59-1 May 61,
by E. W. Frantti. 1 May 61, 75p. incl. illus.
table (Rept. no. 9161-C12C8-2C8(1))
(Contract NObs-77C95)
                          Unclassified report

DESCRIPTORS: (*Thermoelectricity, *Air con-
ditioning equipment for *Submarines, Design,
Theory.) (Refrigeration systems, Heat ex-
changers, Thermal insulation, Vibration.
Shock, Tests.) (Heat transfer ...
water. Cooling

A thermoelectric heating and cooling module was
constructed for installation in a water to water
air conditioning system aboard a submarine.
This module has a cooling rating of 2550 BTU/hr.
at a coefficient of performance of 0.75 and an
operating current of 35 amperes dc. This rating
was based on a 85 F sink water temperature and a
chill water temperature of 55 F. The unit was
designed to withstand submergence pressures and
the corrosive effect of sea water in all water
passages. It occupies a volume 1 ft. by 1 ft.
by 3 inches and was designed for ease in stack-
ing into larger capacity units without additional
space being required for coupling between units.
It has a weight of 50 pounds. (Author)

$$j = 4$$

$$k = 121$$

RAND Corp., Santa Monica, Calif.
THEORY OF IONIZED TRAILS FOR BODIES AT HYPERSONIC
SPEEDS,
by P. S. Lykoudis. 29 May 61, rev. 5 Oct 61,
42p. incl. illus. 26 refs. (Research memo. no.
RM-2682-1-PR, rev. of Research memo. no. RM-2682,
AD-257 938)
(Contract AF 49(638)700, Proj. RAND)
                          Unclassified report

DESCRIPTORS: (*Condensation trails, Bodies
of re... *Hypersonics.) (Aerodynamic
...rations, Thermodynamics, *Gas ioniza-
tion, Velocity, Enthalpy.) (*Re-entry aero-
dynamics, Heat transfer, Thermal conductivity.)

The characteristics of the gaseous trail remain-
ing behind a body moving through the atmosphere
at hypersonic speeds are discussed. Means are
sought for ascertaining those variables that can
be measured and used to predict the character-
istics of the body causing the trail. The avail-
able theoretical and experimental literature is
reviewed and the basic aspects of hypersonic
trails are presented. In the case of thermody-
namic equilibrium, a universal solution is found
for the velocity and enthalpy distributions at
a station behind the body where the pressure has
reached its ambient free-stream value. The
thermal-conduction part of the trail is also
studied. An analytic solution is found for the
case of variable thermal conductivity. The
length of the trail based on a minimum ioniza-
tion level is calculated at different altitudes
for an illustrative re-entry. The influence of
the trailing shock on the conduction part of
the trail is discussed. A preliminary study is
also made of the trail under chemically frozen
conditions. (Author)

$$j = 4$$

$$k = 121$$

Fig. 7 (Continued)

AD-269 507   Div. 13, 12, 4
(TISTM/EJH) OTS price $2.50

Battelle Memorial Inst., Columbus, Ohio.
STUDY OF A CARBON DIOXIDE REDUCTION SYSTEM.
Rept. for 1 May 59-31 Dec 60 on Equipment for
Life Support in Aerospace,
by John F. Foster and Justin S. McNulty. Aug 61,
104p. incl. illus., tables, 18 refs.
(Contract AF 33(616)6332, Proj. 6373)
(ASD TR 61-388)   Unclassified report

DESCRIPTORS: (*Carbon dioxide, *Decomposition,
*Reduction, High temperature research, Radia-
tion effects, Photochemistry, Alkali metals,
Alkali metal compounds, Hydrides, Hydrogen,
Catalysis, Catalysts, Iron, Water, Separation,
Carbon deposits.) (Water, Electrolysis.)
(Spaceships, Satellite vehicles, *Air con-
ditioning equipment, Production, Oxygen.)

An engineering model of a system for reducing
CO2 at a rate of 500 cc/min by reaction with H
over heated catalysts was developed. The pri-
mary products of the reaction were solid C and
water vapor. To recover breathable O, condensed
water vapor would be fed to an electrolysis cell;
the H by-product of the electrolysis would then
be used to reduce more CO2. Solid carbon is re-
moved periodically from the apparatus and dis-
carded. In the final test, the apparatus was
operated continuously for a period of 11 hr. at
about 10% above the target conversion rate. We
estimate that the C deposits could be accumulated
for at least 2 days in the present reactor before
interrupting the process for removal of C and re-
newal of catalyst. With appropriate maintenance
procedures, the apparatus should operate for the
specified maximum of 3 yr without difficulty.
(Author)

j = 4

k = 112

AD-269 000   Div. 25
(TISTM/GEC) OTS price $3.60

AeroChem Research Labs., Inc., Princeton, N. J.
PRELIMINARY OBSERVATIONS ON THE EFFUSION COOLING
OF CATALYTIC SOLIDS EXPOSED TO PARTIALLY DIS-
SOCIATED NONEQUILIBRIUM GAS STREAMS,
by Daniel E. Rosner. Oct 61, 28p. incl. illus.
tables, 32 refs. (AeroChem TN-37)
(Contract AF 49(638)300)
(AFOSR-1841)   Unclassified report

DESCRIPTORS: (*Solids, Catalysts, *Film
cooling, *Gases, Pressure, Turbulent boundary
layer, Thermal diffusion, Transport properties,
Heat of formation, Chemical reactions, Reac-
tion kinetics, Thermochemistry.) (Coolants,
Nitrogen, Ethylenes, Ammonia, Nitrogen com-
pounds, Oxides.) Electric discharges.

The consequences of gas phase chemical reaction
between an effusion coolant and chemically
reactive species present in the free stream are
discussed with regard to convective energy trans-
fer to catalytically active solids. A porous
Cu surface was exposed to a supersonic stream
of activated N. The relative effectiveness of
ethylene, NH3, N, and NO2 as coolants was marked-
ly altered by the effects of specificity in their
gas phase chemical behavior. This suggested that
differences in gas phase chemical reactivity
could be used in selecting effusion coolants for
catalytically active solids exposed to high
temperature partially dissociated streams.
(Author)

j = 4

k = 112

Fig. 7 (Continued)

44

Rocket Research Lab., Ohio State U., Columbus.
MAGNETOHYDRODYNAMIC EFFECTS ON EXOTHERMAL WAVES.
I.   THEORETICAL PROBLEMS ON A MACROSCOPIC SCALE.
II. EXPERIMENTAL STUDY WITH HYDROGEN-OXYGEN
DETONATION WAVES.
Rept. on Research on Combustion Kinetics,
by Michael C. Fong, Loren E. Hollinger and
Rudolph Edse. Sep 61, 90p. incl. illus. tables.
25 refs.
(Contract AF 33(616)5615, Proj. 7013)
(ARL 69)   Unclassified report

DESCRIPTORS: (*Magnetohydrodynamics, Gas
flow, Gas ionization, Chemical reactions,
Heat, Flames, *Electromagnetic waves,
Hall effect, Thermodynamics, Thermal con-
ductivity, Hydrogen, Oxygen, Shock waves.)
(Experimental data, Tables of Chemical
properties, Physical properties.) (Partial
differential equations, Linear systems,
Perturbation theory.)

Various problems associated with the macroscopic
magnetohydrodynamic effects on an exothermal
wave were treated on the basis of one-dimen-
sional flow considerations. A steady exothermal
wave traveling in an ionized medium under the
influence of a transverse magnetic field was
found to display properties similar to those
of a classical detonation or deflagration wave.
For a hydromagnetic exothermal wave, it was
found that a discontinuity either in thermo-
dynamic quantities or in magnetic field strength
appears as soon as the flow reaches the transi-
tion region.

$j = 4$
$k = 112$

California U., Berkeley.
STRONG INTERACTION WITH SLIP BOUNDARY CONDITIONS.
Rept. on Research on Aerodynamic Flow Fields,
by J. Aroesty. Sep 61, 25p. illus. 25 refs.
(Contract AF 33(616)6161, Proj. 7064)
(ARL-64)   Unclassified report

DESCRIPTORS: (*Airfoils, Aerodynamics,
*Hypersonics, Shock waves, *Boundary layer,
Interference, Pressure, Drag, Heat transfer,
Mathematical analysis.)

A solution to the problem of strong interaction
between the shock wave and the boundary layer has
been obtained for the case where velocity slip
and temperature jump boundary conditions are con-
sistent at the wall. It is shown that the addi-
tion of slip boundary conditions yields a
correction of order (boundary layer thickness/X)
to the no slip solution. Estimates are made of
the effect of slip on induced pressures and skin
friction for the case of the adiabatic wall. In
addition, it is shown that the inclusion of slip
boundary conditions does not change the energy
transfer to the wall from the no slip values.
(Author)

$j = 4$
$k = 022$

Fig. 7 (Continued)

AD-269 584   Div. 10
(TISTA/SEB) OTS price $0.10

Lockheed Aircraft Corp., Marietta, Ga.
MAIN PROPELLANT TANK PRESSURIZATION SYSTEM STUDY
AND TEST PROGRAM. VOLUME III. DESIGN HANDBOOK.
Final rept., 1 July 60-31 Oct 61.
Dec 61, 95p. incl. illus. tables, 11 refs. (Rept.
no. ER 5296)
(Contracts AF 04(611)6087 and AF 04(611)7032,
Proj. 6753)
(SSD TR 61-21, vol. 3) Unclassified report

  DESCRIPTORS: (Liquid rocket propellants,
  *Propellant tanks, Pressure, Configuration,
  Geometry, Volume, Design, Military require-
  ments, Mathematical analysis, Handbooks.)
  (Gas generating systems, Rocket fuels, Rocket
  oxidizers, Vaporization, Combustion.)
  (Gases, Liquefied gases, Oxygen, Hydrogen,
  Hydrazines, Methyl hydrazines, Nitrogen com-
  pounds, Tetroxides, Storage.) (Propellant
  tank liners, Materials, Metals, Physical
  properties.) Heat exchangers.

Design information on liquid propellant tank
pressurization systems is presented. The areas
covered are: pressurization gas requirements,
including hand calculation procedures and nomo-
graphs; tankage, including material properties
and volume and wall area curves; and components,
including stored He system weight curves and a
simple but accurate heat exchanger design method.
(Author)

j = 4
k = 013

AD-269 584   Div. 1
(TISTA/VGW) OTS price $0.10

General Dynamics/Convair, San Diego, Calif.
DEVELOPMENT OF A HIGH-TEMPERATURE, NUCLEAR-
RADIATION-RESISTANT PNEUMATIC POWER SYSTEM FOR
FLIGHT VEHICLES
Quarterly rept., 25 Sep-25 Dec 61.
25 Dec 61, 95p. incl. illus. (Rept. no. ZR-
11 1-11)
(Contract AF 33(616)7592)
                              Unclassified report

  DESCRIPTORS: (*Pneumatic systems, Resistance,
  Temperature, Thermal radiation, High tempera-
  ture research, Radiation damage, Radiation ef-
  fects.) (Aircraft equipment, Turbo-ramjets,
  Compressors, Rotary compressors, High pressure
  compressors, Compressed air, Pneumatic systems,
  Control systems, Hydraulic power systems,
  Design.) (*Pneumatic devices, Pneumatic valves,
  Pneumatic servomechanisms, High pressure
  valves, Check valves, Pressure regulators,
  Control valves.

The development status of the rotary actuator
and servo valve, pressure regulator, relief
valve, accumulator, filter and check valve as
well as the turbo-compressor are discussed.
Progress was made on refining the test program
for the tube fittings and boss seals. A high-
temperature facilities survey was undertaken to
evaluate instrumentation, procedures, and safety
regulations used by other companies concerned
with high-temperature and nuclear radiation test-
ing. Results of this survey are also included.
Initial preparations were undertaken to prepare
the high temperature test laboratory for the
test phase. Modification of the environmental
chamber and air heater are underway. Instru-
mentation requirements were reviewed and prelim-
inary procurement was initiated on long lead
time test equipment. (Author)

j = 3
k = 210

Fig. 7 (Continued)

46

AD-269 387   Div. 27, 10
(TISTA/SER) OTS price $10.50

General Electric Co., Cincinnati, Ohio.
OBSERVED EMISSIVITIES OF ROCKET COMBUSTION GASES.
Final rept.,
by D. E. Robison and S. J. Van Grouw.   Dec 61,
132p. incl. illus. tables, 15 refs.
(Contract AF 49(638)413)
(AFOSR-1904)   Unclassified report

   DESCRIPTORS: (Rocket motors, Liquid rocket
   propellants, Combustion, *Combustion chamber
   gases, *Exhaust gases, Pressure, Temperature,
   *Thermal radiation, Infrared radiation, In-
   frared spectroscopy, Detection, Measurement,
   Tests, Theory, Mathematical analysis.) (Nitric
   acid, Ammonia, Hydrazines, Nitrogen compounds,
   Tetroxides.) (Test equipment, Infrared de-
   tectors, Thermopiles, Detectors.) (Test meth-
   ods, Spectrographic analysis.)

The total and the spectral intensity of the
radiation emitted by rocket combustion products
at high pressure was studied. Spectral and
total radiation data are presented for 3 rocket
propellant systems: HNO3 and UN3; N2O4 and
NH3; and N2O4 and N2H4. Each of the combinations
contained H2O as the principal radiating gas.
The measurements were made at a nominal combus-
tion pressure of 700 psia. Emissivity cor-
relations and methods of estimating the tempera-
ture of the combustion gases are developed. A
technique is given for obtaining direct observa-
tion of high temperature gases inside the com-
bustion chamber of a small rocket motor.

j=3
k=210

AD-269 141   Div. 9, 15
(TISTP/MFA) OTS price $1.60

Yeshiva U., New York.
INVESTIGATION OF A VARIATIONAL PRINCIPLE FOR
OPEN SYSTEMS,
by J. L. Lebowitz and E. Merris. 1961, 14p.
12 refs.
(Contract AF 49(638)753)
(AFOSR-1619)   Unclassified report

   DESCRIPTORS: (*Fluid flow, *Heat transfer,
   Hydrodynamics, Thermodynamics, Energy, Chemical
   equilibrium, Entropy, Thermal conductivity,
   Particles, Transport properties.) (*Calculus
   of variations, Partial differential equations,
   Tensor analysis.)

An attempt to obtain information about the
stationary nonequilibrium state of a fluid
through which heat is flowing is described. The
fluid is in contact with several heat reservoirs
at different temperatures and is assumed to be
described by an ensemble density which satisfies
a generalized Liouville equation. Our method
consists of minimizing a positive functional
which vanishes only when the correct stationary
space distribution is assumed. (Author)

j=3
k=120

Fig. 7   (Continued)

AD-26 731   Div. 25
(TISTP/MFA) OTS price $2.60

Aerospace Corp., El Segundo, Calif.
HEAT DISSIPATION THROUGH DIODE LEAD WIRES UNDER
STEADY-STATE CONDITIONS,
by W. D. Buckman. Oct 61, 20p. incl. illus.
tables (Rept. no. TDR-930(2121)TN-1)
(Contract AF 04(647)930)
Unclassified report

DESCRIPTORS: (*Heat transfer, Diodes, Wire,
*Conductors, Nickel, Copper, Thermal conduc-
tivity, Electric connectors, Tests, Thermo-
dynamics.) (Experimental data, Tables,
Functions, Equations.)

Results of an investigation of the capabilities
of wire leads to function as heat dissipating
media are presented. Experimental work related
to this project has confirmed that leads may
serve as heat sinks to an extent greater than has
generally been recognized, and has also served
as a basis for derivation of the theoretical
relationships which define the significant param-
eters involved. The experiments were conducted
to generally determine the effects of varying
wire lead materials, lengths, and diameters under
both radiative and convective ambient conditions.
The mathematical relationships which have been
obtained provide quantitative methods for pre-
dicting the effect and behavior of component-
generated heat on performance, and will permit
better correlation between component wattage rat-
ings as stated by the manufacturer and noted by
the user. (Author)

$$j = 3$$

$$k = 120$$

AD-264 514   Div. 25, 4, 30
(TISTM/TCG) OTS price $2.60

Callery Chemical Co., Pa.
DETERMINATION AND ANALYSIS OF THE POTENTIALITIES
OF THERMAL ENERGY STORAGE MATERIALS.
Quarterly rept. no. 2, 1 Oct-31 Dec 61,
by H. W. Wilson. 31 Dec 61, 18p. incl. illus.
tables.
(Contract AF 33(616)7224)
Unclassified report

DESCRIPTORS: (*Materials, High temperature
research, Storage, Thermodynamics, Heat of
fusion, Thermal conductivity, Energy, Specific
heat, Analysis.) (*Containers, *Crucibles,
Alloys, Additives, Chromium, Liquids, Melting,
*Lithium compounds, *Borates, Corrosion
inhibition.) (*Calcium compounds, Silicides,
*Sodium compounds, Fluorides.) (Laboratory
equipment, *Calorimeters, *Laboratory furnaces,
Tests.)

Extensive tests were conducted to find a metal
suitable as a container for molten LiBO2 at
1600 F. Test results indicated an increasing
corrosion resistance with increasing Cr content
of the alloys. Additional tests are scheduled
with alloys containing a high percentage of Cr.
Drop-calorimetric measurements on CaSi2 produced
heat content data to 470 C. The thermal con-
ductivity apparatus was modified. Measurements
were made on molten NaF at 1020 C; an approxi-
mate thermal conductivity value of 5.7 btu/hr
sq ft F/ft was obtained. Construction of the
furnace-calorimeter apparatus for measurement
of heat release rates was completed except for
the Ni calorimeter block. (Author)

$$j = 3$$

$$k = 120$$

Fig. 7   (Continued)

48

AD-269 196   Div. 27, 11, 14
(TISTM/EJH) OTS price $13.10

Bendix Products Div., Bendix Corp., South Bend,
Ind.
MATERIALS PROPERTY DATA.

Quarterly progress rept. no. 3 on Phase 1,
1 Oct-31 Dec 61,
by James W. Yates.   Jan 62, 1v. incl. illus.
tables.
(Contract AF 33(616)8086)
                          Unclassified report

DESCRIPTORS: (Friction brakes, *Brake linings,
Materials, Metals, Alloys, Additives, Graphite,
Aircraft.) (Tests, Test equipment, Test facil-
ities, High temperature research.) (Erosion,
Deposits.) (*Rocket motors, *Rocket motor
nozzles, Materials, *Refractory materials, In-
sulating materials, Thermal insulation, *Re-
fractory coatings, Cermets, Ceramic materials,
Silicon compounds, Beryllium compounds, Zir-
conium compounds, Magnesium compounds, Oxides,
Tungsten, Steel, Tungsten alloys, Molybdenum
alloys, *Graphite, Heat resistant polymers.)

Contents:
High temperature - high friction materials
  Lining compositions
  Procedures
  Data
Rocket motor material evaluation
  Test facilities
  Jet piercing torch data
  Final report on 20 firings on 3.75 in. Rocket
  Data from 10 firings on 3.75 in. Rocket
  Final report on 10 firings on 5.75 in. Rocket
  Data from 7 firings on 5.75 in. Rocket

j=3

k=120

AD-269 603   Div. 14, 4, 1
(TISTM/EJH) OTS price $7.60

Midwest Research Inst., Kansas City, Mo.
HIGH TEMPERATURE RESISTANT TRANSPARENT PLASTICS.
Final rept., 15 Feb-14 Oct 61,
by Howard Christie and Thomas Medved. 31 Oct 61,
63p. incl. illus. tables, 10 refs.
(Contract NOw 61-0673-d; Continuation of Contract
NOs(s) 60-6099-c)
                          Unclassified report

DESCRIPTORS: (*Transparent panels, *Optical
materials, *Optical plastics, *Optical coat-
ings, *Heat resistant polymers, *Epoxy resins,
Acrylic resins, Resins, Plastics.) (Phthalic
acids, Anhydrides, Vinyl radicals, Cyclo-
hexenes, Dioxides.) (Epoxides, Heterocyclic
compounds, Processing, Aging, Synthesis.)
(Ultraviolet radiation, Radiation damage,
Light transmission, Mechanical properties,
Aircraft finishes, Supersonic planes.) High
temperature research.

Purification of the diglycidyl ether of bisphenol
A (DEBA) by vacuum distillation and decoloriza-
tion of the trimethoxyboroxine (TMB) catalyst
produced colorless starting materials. Reaction
of these materials produced a water-white resin.
After curing in vacuum, the 0.25 in. thick
castings had a luminous transmission of 88%.
Small quantities of low color epoxy novolac res-
in were obtained by molecular distillation of
a commercial product. The distillate reacted
rapidly with TMB to form a hard solid with much
lower color than obtained from any previous
resin of this type. Cast resins obtained from
hexahydrophthalic anhydride and vinylcyclohexene
dioxide were extremely notch sensitive and
brittle. (Author)

j=3

k=120

Fig. 7 (Continued)

AD-269 753   Div. 17
(TISTH/GEC) OTS price $2.50

Materials Processing, TAPCO, Thompson Ramo
Wooldridge, Inc., Cleveland, Ohio.
DEVELOPMENT AND EVALUATION OF HIGH TEMPERATURE
PROTECTIVE COATINGS FOR COLUMBIUM ALLOYS. PART
II. COATING EVALUATION,
Rept. for Apr 60-June 61 on Metallic Materials,
by R. A. Jefferys and J. D. Gadd. Sep 61,
103p. incl. illus. tables.
(Contract AF 33(616)7215, Proj. 7351)
(ASD TR 61-66, pt. 2) Unclassified report

DESCRIPTORS: (*Refractory coatings, *Niobium
alloys, Titanium alloys, Molybdenum alloys,
Tungsten alloys, Zirconium alloys, *Niobium,
High temperature research, *Heat resistant
alloys.) (Oxidation, Erosion, Thermal
stresses, Mechanical properties.) *Oxidation
inhibitors.

A comparative evaluation was made of 18 coating-
base metal systems, six different coatings
applied to 3 Nb base materials (D-31 alloy, F-48

alloy and unalloyed Nb). The 18 coating-base
metal systems were tested under the same condi-
tions in cyclic oxidation (2300 and 2500 F),
thermal shock (2500 to 250 F), bend-oxidation
(2500 F) and stress-oxidation (2500 F) plus
tensile tests. The tests produced directly
comparable data between the coating-base metal
systems relating to the protective nature of each
coating and the effect of the coating and the
coating treatment on the mechanical properties
of the substrate. (Author)

J=3
k=120

AD-269 712   Div. 27, 9, 25
(TISTP/WH) OTS price $1.60

RAND Corp., Santa Monica, Calif.
AN ADIABATIC-ISOTHERMAL NOZZLE,
by V. P. Stepanchuk, tr. by Joy B. Ganley.
Dec 61, 10p. 3 refs. (Rept. no. RM-2930-PR)
(Trans. from Inzhenerno-Fizicheskii Zhurnal
(Journal of Engineering Pysics) vol. 2,
pp. 66-71, 1959)
(Contract AF 49(638)700, Proj. RAND).
Unclassified report

DESCRIPTORS: (*Nozzles, Design, *Adiabatic
gas flow, Mathematical analysis, Numerical
methods and procedures, Equations of State,
Thermodynamics.) (*Adiabatic gas flow,
*Compressible flow, Thermal expansion, Heat
of reaction, Equations of state.) Aero-
dynamics, USSR.

A method is presented for the nozzle calculation
for a chemically active flow at a constant
static temperature. (Author)

J=3
k=III

Fig. 7 (Continued)

50

j=3

k=III

j=3

k=030

*Those terms were not included on the
magnetic tape.

Fig. 7 (Continued)

AD-269 553   Div. 25, 30
(TISTP/WH)   OTS price $10.50

Lockheed Aircraft Corp., Marietta, Ga.
MAIN PROPELLANT TANK PRESSURIZATION SYSTEM
STUDY AND TEST PROGRAM. VOLUME IV. COMPUTER
PROGRAM.
Final rept., 1 July 60-31 Oct 61.
Dec 61, 136p. incl. illus. tables. (Rept. no.
ER-5296)
(Contracts AF 04(611)6087 and AF 04(611)7032,
Proj. 6753)
(SSD TR 61-21, vol. 4) Unclassified report

  DESCRIPTORS: (Guided missiles, Fuel tanks,
  *Propellant tanks, *Heat transfer, Aerodynamic
  heating.) (Thermodynamics, Equations, Dig-
  ital computers, *Programming.) (Pressure
  tanks, Gases, Heat transfer.)

A computer program which can be used to determine
the pressurizing gas requirements for a missile
propellant tank pressurization system is de-
scribed. The program is applicable to both
cryogenic and storable propellants when pres-
surized with stored gas, evaporated propellant,
and main tank injection methods of
pressurization. (Author)

j = 3
k = 021

AD-2??081   Div. 25, 4
(TISTM/GEC) OTS price $2.60

Naval Ordnance Lab., White Oak, Md.
THERMODYNAMIC PROPERTIES OF POLYETHYLENE,
by R. W. Warfield and M. C. Petree. 3 Aug 61,
1?p. incl. illus. tables. 18 refs. (Rept. no.
NOLTR 61-92)
                        Unclassified report

  DESCRIPTORS: (*Polymers, *Ethylene, *Thermo-
  dynamics, Specific heat, Entropy, Enthalpy,
  Transition temperature, Theory.)

The lack of fundamental data on the properties
of polyethylene prompted a study of the avail-
able thermodynamic parameters of this material
From published data the entropy, enthalpy, and
Gibbs free energy values of conventional high
pressure polyethylene were calculated over the
range (to ?1? K. The use of a linear Tarassov
function to estimate the specific heat of poly-
ethylene is discussed. The thermodynamic func-
tion, Cp/T versus T, has been calculated and
exhibits an increase at (? K. An approximation
is made of the number of vibrating units per re-
peating unit at ?7? K. Cp-Cv is calculated at
2? K and found to be ?.08? cal/deg gm. (Author)

j = 3
k = 021

Fig. 7 (Continued)

52

Westinghouse Electric Corp., Pittsburgh, Pa.
OXIDATION OF TUNGSTEN AND TUNGSTEN BASED ALLOYS.
Rept. for Aug 59-Dec 60 on Metallic Materials,
by P. E. Blackburn, K. F. Andrew and others.
June 61, 74p. incl. illus. tables, 22 refs.
(Contract AF 33(616)5770, Proj. 7351)
(WADC TR 59-575, pt. 2) Unclassified report

DESCRIPTORS: (Refractory materials, *Tungsten,
*Tungsten alloys, Tantalum alloys, *Oxidation,
Chemical reactions, Reaction kinetics, High
temperature research, Tungsten compounds,
Oxides, Vapor pressure, Thermodynamics, Heat
of formation.) (Test equipment, Vacuum
furnaces, Temperature, Pressure, X-ray dif-
fraction analysis, Microphotography, Heating,
Induction heating.)

The results of studies related to the oxidation
of W and its alloys are studied. The pressure
of WO3 polymers over WO2 was measured in a W
Knudsen cell and found to agree with measure-
ments in a Pt cell. Literature data for WO2
WO3 were combined with vapor pressures deter-
mined in this project to give thermodynamic
values for W18049 and W20058. W oxidation rates
were measured from 800 to 1700 C and in O pres-
sures between 0.2 and 0.02 atmospheres. The
effects of O pressure indicate that the rate
may be governed by O dissociating to atoms at
the reacting surface. The oxidation rate is dem-
onstrated to be independent of the oxide evapora-
tion rate. All of the evidence indicates that
if an oxide barrier layer is present at tempera-
tures above 800 C it must be very thin. Studies
on the oxidation of Ta - W alloys between 800
and 1200 C indicate that the 50-50 alloy has the
greatest oxidation resistance, oxidizing at a
rate as much as 10 times slower than W alone.
(Author)

j = 3
k = 021

Aerospace Information Div., Washington, D. C.
SOVIET NUCLEAR INSTRUMENTATION AND CONTROL FOR
PROPULSION.
Monthly rept. no. 9, 10 Sep-10 Nov 61.
11 Dec 61, 15p. incl. illus. 7 refs. (AID rept.
61-152)
                        Unclassified report

DESCRIPTORS: (*Gamma counters, *Scintillation
counters, Design.) (Gas flow, Measurement,
*Flowmeters, Design.) (*Heterogeneous reac-
tors, Nuclear reactions, Reactor reactivity,
Critical assemblies, Reactor theory.) (Nuclear
power plants, *Fuel elements, Radioactive
waste.) (Low pressure research, *Pneumatic
servomechanisms, Automatic, Control systems,
Design.) (*Liquid metals, Heat transfer,
Turbulent flow, Fluid flow in Pipes.)

Contents:
Differential method for determining the effi-
ciency of a gamma counter
Pneumatic integrator with aperiodic unit throttle
operating in the low-pressure range
Fast neutron scintillation counter with low
sensitivity to gamma background
New principle for measuring gas flow
Experimental study of the effects of interaction
between two subcritical reactors (Investigation
of the critical parameters of reactor systems;
collection of articles)
Investigation of the spent fuel elements of the
First Nuclear Power Plant
Heat transfer in turbulent flow of liquid metals
in pipes

j = 3

k = 021

Fig. 7 (Continued)

AD-269 628   Div. 12, 9
(TISTA/WAW) OTS price $1.60

Foreign Tech. Div., Air Force Systems Command,
Wright-Patterson Air Force Base, Ohio.
HEAT EXCHANGE AT THE FRONTAL POINTS OF BLUNT
BODIES WASHED BY A SUPERSONIC GAS FLOW,
by V. P. Motulevich. 7 Aug 61, 16p. incl. illus.
(Trans. no. MCL-1108/1 of Konvektivnyy i
Luchistyy Teploobmen, Moscow, pp. 16-24, 1960)
                    Unclassified report

DESCRIPTORS: (*Blunt bodies, Aerodynamics,
Supersonics, Aerodynamic heating, Heat trans-
fer, Mathematical analysis, USSR.)

j = 3

k = 021

AD-269 148   Div. 22, 14, 4, 25, 9
(TISTA/SEB) OTS price $8.10

Army Rocket and Guided Missile Agency,
Huntsville, Ala.
QUARTERLY RESEARCH REVIEW NO. 30, 1 MAY-
31 JULY 61.
1 Nov 61, 80p. incl. illus. tables, 36 refs.
(Rept. no. ARGMA TN 2H1N-30)
                    Unclassified report

DESCRIPTORS: (Reinforcing materials, Glass
textiles, *Phenolic resins, Mechanical prop-
erties.) (*Boron, Preparation, Purifica-
tion.) (Nuclear physics, *Radioactive decay.)
(Ethylene, Nitrogen compounds, Fluorides, Com-
bustion.) (Electronics, Atmospherics, *Noise
analyzers, Theory.) (Gases, *Magnetohydrody-
namics, Plasma physics, Plasma jets, High tem-
perature research.) (*Hypersonic wind tunnels,
Hypersonics, Re-entry aerodynamics, Aerody-
namic heating, Simulation.) (Solid state
physics, Electrons, Transport properties.)

Contents: MATERIALS (Mechanics of materials and
structures and preparation of high purity boron);
NUCLEAR PHYSICS (Isomeric yields from (n, 2n)
reactions); FUELS AND COMBUSTION (Burning rates
of ethylene-NF3); PHYSICAL ELECTRONICS (Spectrum
of amplitude-modulated noise after square-law
detection II); HIGH TEMPERATURE PHYSICS (Simpli-
fied probe theory III, Plasma jet in probe meas-
urements, Analysis of probe data by simplified
double probe theory, Graphs for the truncation
of partition functions of selected elements,
Control system for the hyperthermal test facil-
ity, and Electron capture in a magnetic field);
and SOLID STATE PHYSICS (Transport of fast
electrons).

j = 3

k = 021

Fig. 7 (Continued)

AD-269 160   Div. 17, 27, 1, 20
(TISTM/GEC) OTS price $7.60

Foreign Tech. Div., Air Force Systems Command,
Wright-Patterson Air Force Base, Ohio.
INVESTIGATIONS OF HEAT RESISTANT ALLOYS (SELECTED
ARTICLES),(Issledovaniye Zharoprochnykh Splavov
(Trudy 123)).
4 Dec 61, 69p. 11 refs. (Trans. no. FTD-TT-61-31
of Gosudarstvennoye Nauchno-Tekhnicheskoye
Izdatel'stvo Oborongiz, Moskva, pp. 17-34,
45-52, and 65-68, 1960)
                    Unclassified report

DESCRIPTORS: (*Heat resistant alloys,
*Corrosion-resistant alloys, High temperature
research, Stainless steel, Austenite, Steel,
Titanium alloys, Aluminum alloys, Tungsten
alloys, Silicon alloys, Chromium alloys,
Boron alloys.) (Tests, Crystal structure,
Grains (Metallurgy), Mechanical properties,
Physical properties, Surface properties.)
(Aircraft, Hypersonics, Supersonic planes,
Gas turbine blades for jet engines, Nuclear
power plants.) USSR.

Contents:
Selective alloying as a method for improving
heat resistance, by S. N. Vinarov
Investigation of the dependence of the structure
and properties of gas turbine blades on the
duration of operations, by S. T. Kishkin,
A. A. Klypin, N. V. Koryakina
Strength of alloys in contact with Na, by S. T.
Kishkin, and G. P. Benediktova
High temperature corrosion resistance, by G. N.
Dubinin

j = 3

k = 021

AD-270 081   Div. 12
(TISTA/SEB) OTS price $1.00

National Aeronautics and Space Administration,
Washington, D. C.
DETERMINATION OF NUCLEAR-ROCKET POWER LEVELS FOR
UNMANNED MARS VEHICLES STARTING FROM ORBIT ABOUT
EARTH,
by Richard H. Cavicchi and James W. Miser.
Jan 62, 40p. incl. illus. 8 refs. (NASA Techni-
cal note D-474)
                    Unclassified report

Also available from NASA, Wash. 25, D. C. as
NASA Technical note D-474.

DESCRIPTORS: (Space flight, *Space probes,
Mars, Spaceships, *Nuclear propulsion,
Hydrogen, Temperature, Thrust, Specific
impulse, Design, Feasibility studies, Military
requirements, Theory, Mathematical analysis.)

Nuclear-powered Earth-orbital-launch probes can
place greater payloads in orbit about Mars than
chemical vehicles if reactor power exceeds
50 mw. Suitable reactor powers for this mission
are about 150, 400, and 1000 mw for 33,000-,
81,000-, and 200,000-lb vehicles, respectively.
Whereas a 33,000-lb vehicle requires greater
than a 200-day coast, a 145-day coast is fea-
sible for an 81,000-lb vehicle. A hydrogen
temperature of 4000 F in the nozzle appears to
be a good compromise. Use of a solid-propellant
rocket to achieve an orbit about Mars from
coast yields no payload advantage. Using
optimum firing dates, a 33,000-lb vehicle
could orbit an acceptable payload about Mars,
and an 81,000-lb vehicle could land freight on
Mars. (Author)

j = 3

k = 012

Fig. 7 (Continued)

REFERENCES

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    tives and practicalities. In Proceedings of the Third Institute on
    Information Storage and Retrieval, 1961. Available from the Center
    for Technology and Administration, The American University, Washington,
    D. C.

Doyle, L. B. Semantic road maps for literature searchers. Journal of
    the Association for Computing Machinery, vol. 8, 1961, 553-578.

Freud, Sigmund. The basic writings of Sigmund Freud. New York: Modern
    Library, Random House, 1938.

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    In Proceedings of the Third Institute on Information Storage and Re-
    trieval, 1961. Available from the Center for Technology and Adminis-
    tration, The American University, Washington, D. C.

Stiles, H. E. The association factor in information retrieval. Journal
    of the Association of Computing Machinery, vol. 8, 1961, 271-279.

Hq. ESD, L.G. Hanscom Field, Bedford, Mass.
Rpt. No. ESD-TDR-63-159. STATISTICAL ASSOCIATION PROCEDURES FOR MESSAGE CONTENT ANALYSIS (U). Preliminary report, April 1963, 57p. incl illus, 6 refs.

Unclassified Report

This is an introductory report of an investigation concerned with develop-ing procedures for utilizing certain statistical properties of messages or

1. Coding
2. Data processing systems
3. Library science
I. Project No. 702
II. AF33(600)-39852
III. The MITRE Corporation Bedford, Mass.
IV. Spiegel, J.
V. Bennett, E.

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1. Coding
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II. AF33(600)-39852
III. The MITRE Corporation Bedford, Mass.
IV. Spiegel, J.
V. Bennett, E.

documents; these properties to be used
for message routing or retrieval.
This approach applies the most ele-
mentary relation among the words
making up a message, that of word-
word co-occurrence probability
patterns. It is shown that any mes-
sage material, be it natural language,
code, or index terms, can be processed
provided that the input is compatible
with the input requirements of the
computer.   Unclassified Abstract

VI. Vicksell, R.
VII. SR-79
VIII. In ASTIA
      collection